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TO ALL

NATURAL GASOLINE MEN

GREETINGS

FROM THE

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The Course of Oil

by K. C. SCLATER

FIELD ENGINEERING COMMITTEES

In a producing oil and gas reservoir all operators in the pool draw from a common source of supply. They have a common interest in fostering practices that lead to conservation and the economic recovery of oil and gas. Cooperation among operators therefore plays a large part in successful oil field development. One aspect of such cooperation is the free exchange of information derived from operations. This information is in the form of factual field data, from which can be obtained a current picture of reservoir conditions.

Experience has disclosed the benefits that accrue from such cooperation in oil and gas producing operations. Evidence of this is the formation in recent years of field engineering committees. These committees aid in providing a common understanding of reservoir conditions, which are in a state of continuous change as oil and gas are produced. Good operating practices are thus fostered that lead to the efficient conservation of oil and gas. Field problems and the necessity of their quick solution can be discussed objectively. Any detrimental effects to the field because of certain practices are quickly brought to light. Taking common action in such circumstances can be very effective in prolonging the life of a pool. Engineering committees have therefore the advantage of bringing to light incipient detrimental field conditions and the necessity for immediate remedial work before the harmful conditions develop too far.

There are today more than eighteen field engineering committees throughout the country. Their rise in recent years is silent testimony to their success. The organization of field engineering committees has been a matter of evolution. A committee may cover one field or a group of fields; or, as in the case of the Mississippi Oil and Gas Engineering Committee, cover all fields in the state.

An excellent discussion of the history, organization, scope of activities, and legal aspects of field engineering committees was presented before a joint meeting of the Illinois Society of Petroleum Engineers and the Illinois Basin Chapter of the American Petroleum Institute by D. V. Carter, who was instrumental in organizing the Oil and Gas Engineering Committee of the State of Mississippi, of which he is chairman. Organized early in January, 1945, the Mississippi committee is the third statewide engineering committee. Its sole purpose is the collection and dissemination of operating data on all fields in the state. Results, so far as the State of Mississippi is concerned, promise to be far-reaching and of inestimable value. According to Carter, the work of this committee has led to a better understanding of the mechanics of oil and gas reservoirs by the gradual application of technology, legislative help, and the clarifying aid from the courts, and has paved the way toward a realization of oil and gas conservation. Although an infant state so far as the production of oil and gas is concerned, Mississippi, in having such an organization as its Oil and Gas Engineering Committee, has had an auspicious beginning in oil that other oil-producing states might envy. Although the committee has been functioning only one year, data on every oil and gas field in the state have already been compiled.

Figures on the operation and cost of the Mississippi Oil and Gas Committee compiled by Alec M. Crowell are enlightening. According to Crowell, conservation of oil and gas and rapid acceptance and dissemination of good operating practice and systems are being brought about at a cost of only 1/5 cent per barrel of oil and condensate produced. No restrictions are placed on competition in oil and gas operations. The work of the Mississippi committee is confined to geologic, statistical, and factual field information. No agreement or understanding, expressed or implied, with respect to the exploratory and development policy to be pursued exists between members of the Oil and Gas Committee. The information compiled on each oil and gas reservoir of Mississippi makes available a reliable aid in evaluating current economic conditions in that state. The cooperative service rendered has lightened the burden of technical staffs of its oil company members with resulting economies. As the state's oil and gas operations increase, the value and results of the committee's work and its far-reaching benefits will become more apparent.

It is evident from the articles of its organization that much careful planning and foresight, culled from experience with other engineering committees, went into the formation of the Mississippi Committee. The Mississippi Committee's records, comprising as they do data on every well drilled and on every oil and gas field developed, should benefit operators as well as the state and contribute greatly to the conservation of oil and gas. Members of this committee and the director in charge, Mr. Alec N. Crowell, are to be congratulated on a year of remarkable accomplishment—further evidence of the value of field engineering committees in the interest of economy and oil and gas conservation.

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Scanning WASHINGTON'S OIL HORIZON

By MILBURN PETTY

WASHINGTON.—Harold L. Ickes is gone from the Interior Department—but the departmental ambition to be the government's oil policy-maker and to control all oil and gas activities still burns as strongly as ever. And the new secretary, Julius A. Krug, is likely to go along with this idea.

Interior's aim is to take over all non-regulatory functions touching oil or gas. This would include oil and gas leasing of all federal lands, including the Naval Petroleum Reserves. Also, Interior wants to do the economic and statistical studies now being done by other departments and agencies.

U. S. Tariff Commission has been working for months on a report to Congress on how the oil industry was affected by the war. Federal Power Commission has been investigating natural gas resources and other angles, including many that tie in directly with oil. These are two types of jobs that would go to Interior, if President Truman adopts the department's recommendations under the government reorganization program. In other words, Interior would become the fact-finder on oil and gas for the government and Congress.

Of course, Interior wants to be designated as the administrative agency for any oil or gas legislation enacted in the future; for example, if Congress should adopt suggestions for setting up government oil reserves, here and abroad.

Interior has a good start now with jurisdiction over the Continental Shelf (which will begin at low tide, if federal claims are successful). When the oil and gas leasing bill is finally enacted, Interior probably will get control of leasing on all federal lands. Right now, a renewed effort is being made to have Naval Petroleum Reserves transferred to Interior.

During hearings on his nomination to be Navy Undersecretary, Edwin W. Pauley, Los Angeles oil man, suggested that a board of Interior, War and Navy department representatives be set up to acquire and develop government oil reserves.

This was not an appeasement move. It was Ickes' idea originally. He thought Truman had given him the green light. If Truman had held up the controversial nomination for another month, the three-department board (with Ickes as chairman) would probably have been an actuality. Ickes would then have been less inclined to oppose Pauley's confirmation. The day that Ickes went up to the Naval Affairs Committee hearings on Pauley and tore the blanket (his second trip, not the first), the draft of an executive order for a three-department board was on Truman's desk—but unsigned.

Now, the Ickes-less Department of Interior is pushing for a one-department control of oil. But the military, which wasn't in favor of the three-department board before, is now leaning in that direction hoping they can dominate such a set-up.

Some industry leaders would have preferred military control of oil policies in preference to Interior, with Ickes in the saddle. But it may be a different story now.

Certainly, it is more probable than ever that some sort of government oil agency or centralization of oil activities will be set up by Truman, if it doesn't go further than that and include some measure of control. Unsettled world events are bound to increase the urgings of military authorities that steps be taken to assure plenty of oil for another emergency. The Pauley hearings have made the people—and Congress, too—more oil-conscious. The atmosphere is still more explosive with possibilities.

● **PRICE CONTROL.** The 10-cent advance in crude oil price ceilings, plus the hint of another dime or so to come, hasn't lessened demands that OPA take its hand off the oil business. So, it is an even better bet now that oil price control will be suspended this spring, as was predicted several months ago in this column.

OPA is still fighting a rearguard action. Refined product ceilings will be increased to cover the crude advance. Then another hike in crude ceilings will be in order, followed by more raises in product ceilings. By that time, the heating oil season will be over. All oil price ceilings can then be suspended. OPA believes that fuel oil prices must be advanced to close the competitive gap between coal and oil, or else refiners won't be able to meet the increase in demand next winter. So, OPA isn't worried about further rises in fuel oil prices. And gasoline stocks are sufficiently high to prevent a runaway market.

● **BIG INCH.** Oil use of one or both of the Big Inch pipe lines still cannot be counted out of the picture. War Assets Corporation has confirmed reports that it has received a firm bid for oil use of these government-owned lines.

This is in addition to offers from gas interests, who are so anxious to acquire the Big Inch right-of-way that they are willing to keep one of the lines in oil service. One group says it would be willing to operate both lines as common carriers of crude oil or products, if it can build a 30-in. gas transmission line along the Big Inch right-of-way.

Deadline for congressional veto of the Big Inch disposal program has passed, so this report—which favors an all-out effort to keep the lines in oil service as a national defense measure—is now settled government policy. (It is unlikely now that any special hearing will be held for opponents of this report.)

WAC is still studying replies to the 5000 letters sent out to stir up interest among producers, refiners, marketers and cooperatives looking toward their formation of a joint corporation for operation of one or both of the Big Inch lines as oil carriers. But this won't be necessary, if pending proposals go through.

● **ADVISORY GROUP.** With 46 out of 70 members of the now-defunct Petroleum Industry War Council favoring a postwar advisory organization—patterned after the PIWC—and others agreeable to the idea but favoring some other kind of set-up, it seems probable that further moves will be made to have an overall advisory group that will be representative of all elements in the industry. (The idea for a postwar PIWC was dropped because the proposal failed to get a 75 per cent majority as had been agreed.)

Some industry leaders feel this can be accomplished by "democratizing" the American Petroleum Institute. When the API holds its mid-year meeting in May, it will be urged that the presidents of national and regional associations—in all branches—be added to the Institute's board of directors as *ex officio* members.

● **OIL TREATY.** Prospects are not bright for the Anglo-American Oil Agreement. Hearings have been postponed indefinitely at the State Department's request. Secretary Ickes, chief proponent of the oil treaty, has departed from government service under circumstances making it a delight for some senators to knife his brainchild. Industry opposition is mounting, especially from Texas where Senator Tom Connally, Senate Foreign Relations Committee chairman, seeks re-election.

● **OIL AND GAS INVENTORY.** One of Secretary Ickes' last official acts was to order the Interior Department to make an inventory of the country's natural resources, including oil and gas. Plans for the study are being made by the Geological Survey and Bureau of Mines.

● **API SUIT.** With the deadline set for May 20th to plead or otherwise answer charges in the anti-trust against the API and 300-odd other defendants, negotiations have begun for settlement by constant decree. Prior to start of the conferences March 12, Acting Attorney General McGrath denied a newspaper story that the Department of Justice was contemplating dismissal of the API from the case.

● **AVGAS.** Military authorities, plagued by storage problems, may have to reconsider their decision not to sell surplus 100-octane. Millions of barrels are stored at refineries where the space is badly needed for motor gasoline, by-product of the all-out effort to meet military requirements of fuel oil. War Assets Corporation is considering dribbling out about a million barrels each month to refiners for blending with motor gasoline.

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To prevent wild flow through the tubing.

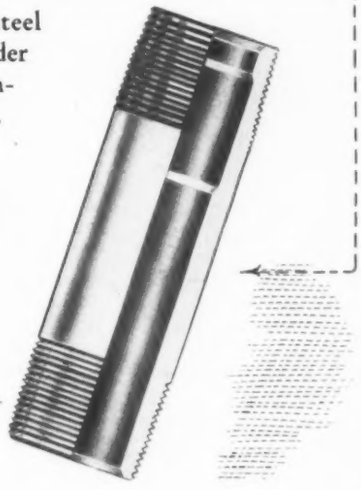
CHOKES
To eliminate freezing of surface connections.

CLOSING TOOLS
To run and pull tubing under pressure.

REGULATORS
To reduce excessively high pressures and stop freezing.

TESTING TOOLS
To test tubing for leaks and breaks before the well is completed.

PLUGS
To shut off tubing flow while repairing surface connections.



If you are completing a flowing well, or pulling tubing for re-work, etc., call the nearest OTIS man *now* about a Type J Landing Nipple - - - - or write, wire, or phone Otis Pressure Control, Inc., Dallas 9, Texas.

OTIS

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NATIONAL PETROLEUM SITUATION

FEEBLE PRICE GESTURE. The 10-cent increase in crude prices granted by OPA is like a drop of one-half degree in the temperature of a very sick patient. The patient is still sick! The increase amounts to 8 per cent (net 7 per cent after royalty), while labor costs have advanced 60 per cent and material and supply costs are up 50 per cent in the last 4 years. The new national average price of $1.33 is 67 per cent of the average wholesale price level of all commodities.

PRODUCTION CUT-BACKS. The need for reduced crude production schedules is shown by analysis of results in first 2 months of this year. Average daily output was 4,703,000 bbl., against actual demand quota of 4,483,000 bbl. Recognition of overproduction is shown by curtailed allowables for March by various states. Texas cut allowable 359,525 bbl.; Oklahoma cut 30,000 bbl.; California cut-back is about 10,000 bbl.

WILDCAT SLUMP. Wildcat operations in the first 2 months of this year were about 11 per cent under last year. On the basis of an annual quota of 5000 wildcats, results were 27 per cent below par. Wildcat completions were 589, against a quota of 808. Development wells, on the other hand, were 14 per cent above expectations since January 1. Development well completions were ahead of last year by 15 per cent. Combined results in first 2 months were within 3 per cent of normal expectations. New drilling operations on March 1 were about 5 per cent below a year ago.

LARGER CRUDE STOCKS. Stocks of crude oil have increased about 9,000,000 bbl. since January 1. This means that the industry has been running crude to storage at the rate of 152,500 bbl. daily since the first of the year. Figures of the Bureau of Mines indicate that Texas crude has been going to storage at the rate of about 119,000 bbl. daily since January 1.

TOO MUCH GASOLINE. Stocks of gasoline on March 1 aggregated about 100,300,000 bbl. This represents an increase since November 1, 1945, of 28,302,000 bbl. Current gasoline stocks represent 54 days' supply, against 38 days last October. Motor fuel demand in first 2 months of this year was 9 per cent under last year, while stocks increased 11 per cent over a year ago.

FUEL OIL SHORTAGE. While the demand for fuel oil is about 2 per cent under a year ago, stocks of light and heavy fuels are about 7 per cent below last year. February figures indicate demand of 65,418,000 bbl. Refinery production, imports, and transfers from crude aggregated about 62,600,000 bbl., a shortage in 1 month of 2,800,000 bbl.

Comparative Statistics, February, 1946

*All figures are computed on a Bureau of Mines' Basis**

	Feb. 1946	Jan. 1946	Feb. 1945	This year to date	Last year to date	Per cent change
Wells drilling	3,860	¶3,950	4,055	3,860	4,055	— 5
Total wells drilled	1,954	2,357	1,820	4,311	3,910	+10
Development wells	1,710	2,012	1,515	3,722	3,250	+15
Oil	1,077	1,264	931	2,341	1,999	+17
Gas	199	201	165	400	358	+12
Dry	434	547	419	981	893	+10
Per cent dry	25.4	27.2	27.7	26.4	27.5	— 1.1
Wildcat wells	244	345	314	589	660	—11
Oil	42	35	42	77	88	—13
Gas	9	9	13	18	23	—22
Dry	193	301	259	494	549	—10
Per cent dry	79.1	87.2	82.5	83.9	83.2	+ 0.7
Crude production	133,960	144,500	133,238	277,460	280,424	— 1
Daily average	4,749	4,661	4,759	4,703	4,753	
Crude demand†	132,475	146,600	138,822	279,075	288,989	— 3
Daily average	4,731	4,729	4,958	4,730	4,898	
Crude stocks	231,750	224,365	226,012	231,750	226,012	+ 3
Days supply	49	47	46	49	46	
Natural gasoline production	8,030	9,025	8,753	17,055	18,356	— 7
Daily average	287	291	313	289	311	
Motor fuel production	54,430	62,240	63,503	116,670	130,165	—10
Daily average	1,944	2,008	2,268	1,977	2,206	
Gasoline yield, per cent	38.5	39.2	41.5	39.0	40.5	— 1.5
Motor fuel demand	52,455	55,315	56,449	107,770	118,147	— 9
Daily average	1,873	1,784	2,016	1,827	2,002	
Motor fuel stocks	100,300	98,240	90,091	100,300	90,091	+11
Days supply	54	55	45	54	45	
Fuel oil production	57,200	62,365	57,408	119,565	119,826	0
Daily average	2,043	2,012	2,050	2,027	2,031	
Fuel oil demand	65,418	78,925	68,282	144,343	146,536	— 2
Daily average	2,336	2,546	2,439	2,446	2,484	
Fuel oil stocks	62,500	65,650	66,970	62,500	66,970	— 7
Days supply	27	26	27	27	27	
Refinery still runs	127,900	141,350	134,882	269,250	279,953	— 4
Daily average	4,568	4,560	4,817	4,564	4,745	
All refined stocks	240,950	242,550	228,437	240,950	228,437	+ 5
Days supply	47	46	42	47	42	

*Unless otherwise stated all figures represent thousands of barrels.
†Domestic and foreign.
¶Revised.

Economic Position of U. S. Petroleum Industry

Two Months Ending February 28, 1946

	Normal	Actual	Per cent of normal
Drilling*** (wells completed)	4,425	4,311	97
Production (daily crude output)	4,483	4,703	105
Refining (daily still runs)	4,621	4,564	99
Stocks (crude and refined)	497,200	472,700	95
Price of crude (per bbl.)	$1.98	$1.33	67

Crude Prices by States for February, 1946§

U. S. average	$1.33	Louisiana	$1.32
Texas	1.31	Arkansas	1.13
California	1.17	New Mexico	1.10
Oklahoma	1.29	Mississippi	1.20
Kansas	1.30	Illinois	1.47
		Other states	1.99

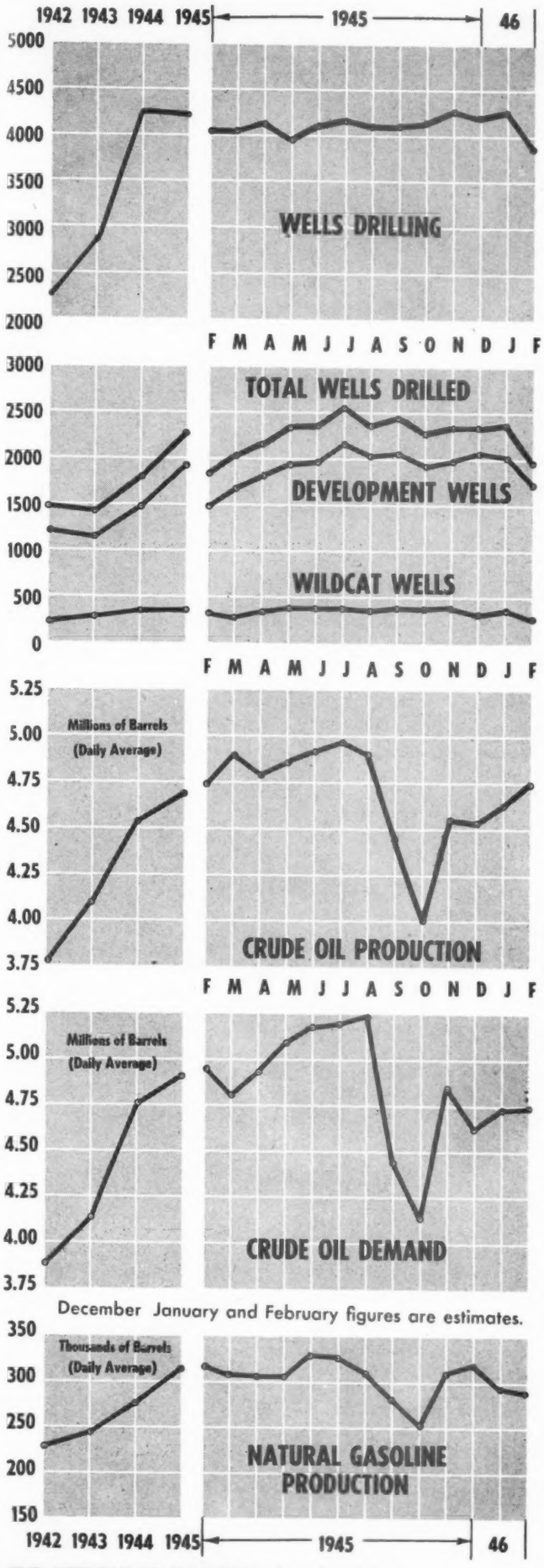
asic crude prices

Oklahoma-Kansas (36 gr.)	$1.37
Texas Gulf Coast (36 gr.)	1.50
East Texas	1.35
West Texas (36 gr.)	1.14
Calif. Signal Hill (26 gr.)	1.21
Pennsylvania Bradford	3.10

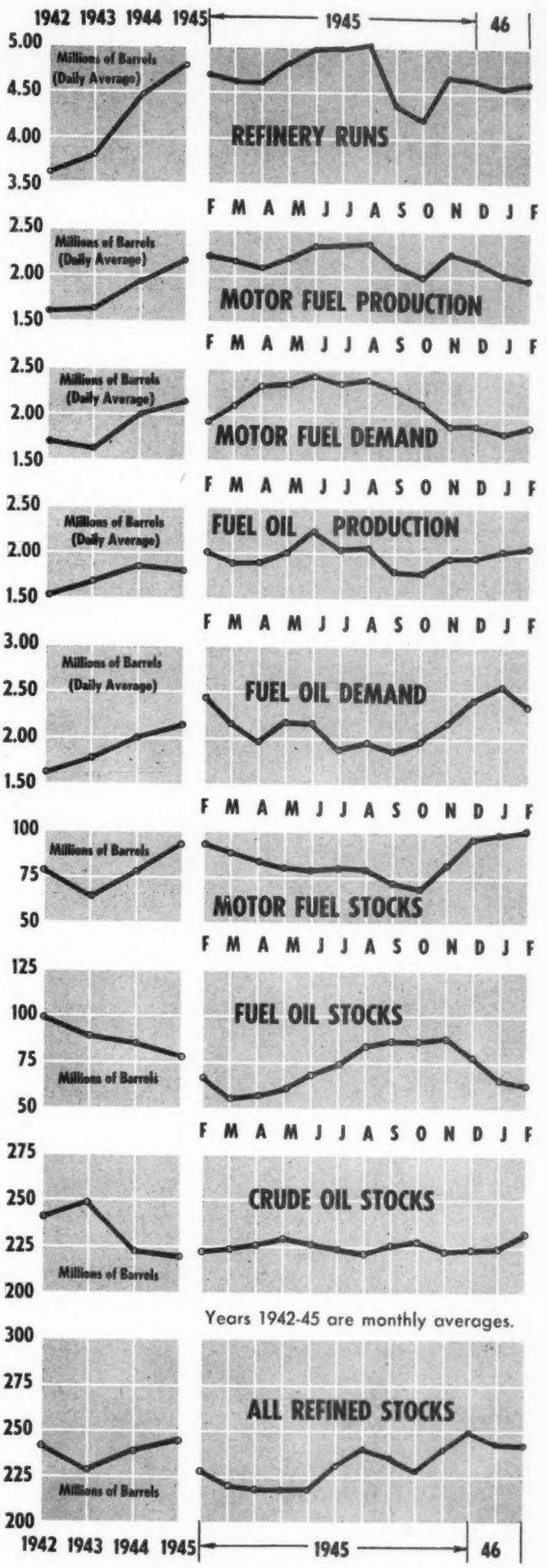
Drilling and Production Statistics by States

	Feb. 1946	Jan. 1946	Feb. 1945	This year to date	Last year to date	Per cent change
Total wells drilled	1,954	2,357	1,829	4,311	3,910	+10
Texas	559	675	558	1,234	1,110	+11
California	124	156	159	280	380	—26
Oklahoma	183	212	177	395	372	+ 6
Kansas	137	191	102	328	214	+53
Louisiana	95	102	67	197	148	+33
Arkansas	19	11	11	30	24	+25
New Mexico	28	44	34	72	75	— 4
Mississippi	14	23	22	37	48	—23
Illinois	135	178	110	313	279	+12
Other states	660	765	589	1,425	1,260	+13
Wildcats drilled	244	345	314	589	660	—11
Texas	92	108	155	200	281	—29
California	14	24	14	38	36	+ 6
Oklahoma	28	54	26	82	60	+37
Kansas	16	31	26	47	61	—23
Louisiana	15	10	8	25	24	+ 4
Arkansas	5	1	7	6	11	—45
New Mexico	2	10	8	12	16	—25
Mississippi	5	5	8	10	18	—44
Illinois	24	41	14	65	50	+30
Other states	43	71	48	114	103	+11
Daily crude production	4,749	4,661	4,758	4,703	4,753	— 1
Texas	2,135	2,055	2,151	2,093	2,155	— 3
California	848	842	898	845	895	— 6
Oklahoma	392	398	362	395	363	+ 9
Kansas	253	249	263	251	266	— 6
Louisiana	368	368	356	368	351	+ 5
Arkansas	77	77	80	77	81	— 5
New Mexico	100	101	105	100	104	— 4
Mississippi	55	54	52	54	50	+ 8
Illinois	215	222	210	218	208	+ 5
Other states	306	295	281	302	280	+ 8

§Prices set by OPA.
(p) Preliminary.
Prices do not include subsidies.
***Does not include input wells.



December January and February figures are estimates.



Years 1942-45 are monthly averages.

Highlights IN OILDOM

● **API URGES ELIMINATION OF PRICE CONTROL.** The American Petroleum Institute will strongly urge upon Congress prompt elimination of price control in the petroleum industry, President William R. Boyd, Jr., has announced.

"Much of the time of the quarterly meeting of the API board of directors held in Washington on March 5," Boyd said, "was devoted to a review of the many evils that beset the producers and consumers of petroleum products as the result of the continuance of inflexible price controls on a commodity that, as a whole, is now in ample supply.

"Interference with the normal seasonal adjustments to reflect consumer demand, such as for gasoline in summer and fuel oil in winter, results."

Several members of the board directly attributed production shortages of domestic and Navy fuel oils to "the unjustified and unrealistic continuance of price controls."

The discussion led to the decision to present to Congress the strongly expressed views of the petroleum industry on the imperative need to remove the regulations. The decision was voiced in the following resolution, which was unanimously adopted, Boyd reported:

"Resolved, that the API Board appoint a Committee of Seven to appear before the appropriate Congressional Committees for the following purposes:

"1. To explain and present supply and demand situation of our industry and the unbalance and inequities created by the operation of peacetime price control.

"2. To summarize the fundamental difficulties with, and bad effects of, price control in peacetime.

"3. To urge and supply the information which justifies prompt elimination of price control in the petroleum industry.

"It is requested that the committee exchange views with the IPAA Committee on the same subject and, if possible, report back to the API Executive Committee before it makes its presentation."

After the meeting, Boyd announced these members of the Committee of Seven, authorized to present the Institute's views on price control to Congress: Chairman, W. S. Hallanan, Plymouth Oil Company, Pittsburgh, Pennsylvania; J. F. Drake, Gulf Oil Corporation, Pittsburgh, Pennsylvania; Eugene Holman, Standard Oil Company (New Jersey), New York, New York; B. Brewster Jennings, Socony-Vacuum Oil Company, Inc., New York, New York; B. L. Majewski, Deep Rock Oil Corporation, Chicago, Illinois; J. Howard Pew, Sun Oil Company, Philadelphia, Pennsylvania, and Robert E. Wilson, Standard Oil Company of Indiana, Chicago.

● **COMPACT MEETING APRIL 11-13.** Men of science will dominate the program of the spring meeting of the Interstate Oil Compact Commission in Tulsa, Oklahoma, April 11-13, Governor Robert S. Kerr, compact chairman, announced in discussing plans for the meeting.

"Dr. Weidlein, director of the Mellon Institute, Pittsburgh, has accepted our invitation to deliver an address at the compact's open session April 13 on developments in industrial research during the war," Kerr said. "He is one of the nation's most outstanding research scientists and his talk will be of great assistance to the compact commission in evaluating the scientific advances made in industrial fields during recent years."

Another nationally known research authority has been invited to speak before the commission's open session April 12, Kerr said, and details of his address will be announced later.

Compact committees will meet all day April 11 and will make formal reports to the commission at the public session the following day. Also scheduled for April 11 is another of the compact's "Little Town Hall Meetings" open to the public and participated in by committee members and industry representatives.

"The Tulsa Hotel has been chosen as headquarters for the meeting," Kerr said, "and requests for reservations already received indicate an unusually large attendance."

● **WATCHING HUNGARIAN SITUATION.** Commenting on recent news dispatches from Budapest, which appeared in the daily press concerning damage to oil fields owned by its Hungarian affiliate, Eugene Holman, president, Standard Oil Company (New Jersey), said that the report was in accord with information previously received from the company's representatives and with similar press dispatches from Hungary published in this country in January.

Holman said that although the problem for some time had been the subject of discussions with the United States Department of State no formal claims have been filed here. Jersey Standard, according to Holman, has kept the Department of State in Washington fully informed and will continue to do so. He emphasized that the company's actions will continue to be guided by the State Department's advice.

Information from Hungary, it was said, indicates that formal statements have been filed with the United States legation in Budapest regarding operations of the oil fields by the Russians. Jersey Standard has received no information of the amount of damages that may have been mentioned in such statements.

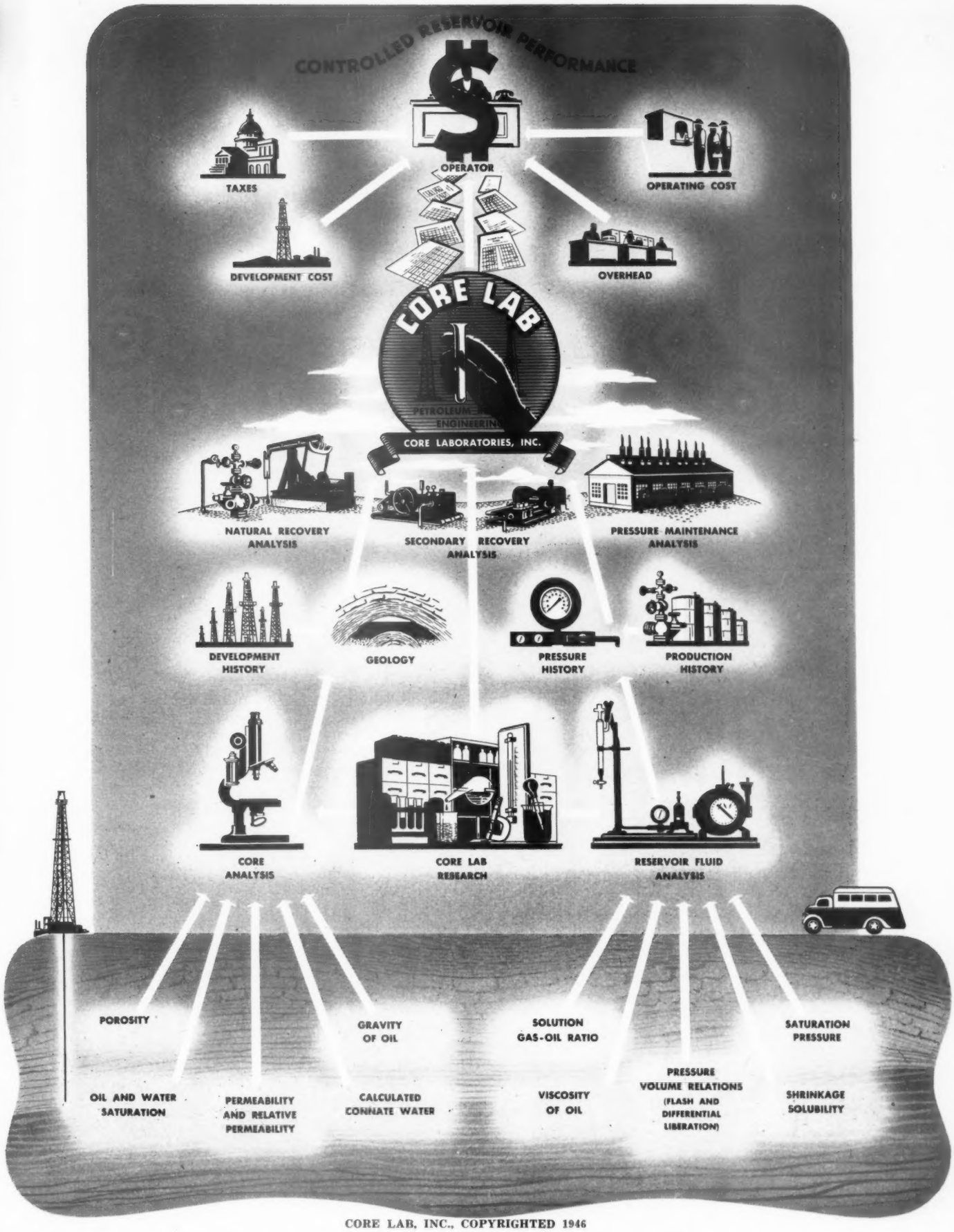
● **PROPOSED KENTUCKY REGULATIONS.** A bill governing the drilling of oil and gas wells, establishing spacing regulations, and providing for unitization of leases for spacing purposes is before the present session of the Kentucky legislature. The state geologist has administration of this Act. Another bill has been introduced providing for setting up of the Kentucky Geological Survey under the state geologist, making it a separate department.

● **OUTLINES FOUR-POINT OIL PROGRAM.** Major B. A. Hardey, president of the Independent Petroleum Association of America, in an address before the North Texas Oil and Gas Association in annual meeting at Wichita Falls, Texas, March 2, outlined a four-point program as prerequisite to a healthy and solvent producing industry. Hardey, independent operator of Shreveport, Louisiana, asserted that the adoption of the entire program is necessary if the producing branch of the oil industry is to remain in business. Under presently existing conditions, he pointed out, the independent producers are threatened with total and absolute extinction.

The program as outlined calls for: First, immediate removal of price restrictions and controls by the Office of Price Administration. Second, a national oil policy on importation of cheap crude oil produced in foreign countries should be adopted by the Congress, and imports should be restricted to the point where they will not stagnate the domestic industry, which is already burdened with high production costs. Third, the different oil producing states through their regulatory bodies should maintain production quotas that are not in excess of consumptive demand. Any production above market requirements induces physical and economic waste. Fourth, the continuation of an equitable tax policy by the Congress, recognizing the hazards peculiar to the business of finding and producing petroleum, is also essential.

"There is no reason to continue price controls in any industry where no scarcity exists," Major Hardey pointed out, "and today the petroleum industry is producing more oil than the market can absorb. Stocks of gasoline have reached an all-time peak, and in many parts of the United States gasoline is now selling below OPA price ceilings. Thus we see that economic forces within the industry are again working to protect the public against unnecessary increase in prices of petroleum products."

Hardey stated that imports of foreign oil during recent weeks have reached an all-time high, and unless import quotas are set by Congress to protect the domestic producer this country will be glutted with cheap foreign oil that will benefit only a few importers, will not benefit the consuming public, but instead will put thousands of crude oil producers out of business and seriously stagnate the entire petroleum industry in this country.



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C O R E L A B O R A T O R I E S , I N C . . . . D A L L A S , T E X A S

MAJOR *Oil Field* ACTIVITIES

● **CALIFORNIA.** Richfield Oil Corporation's discovery well, Vail No. 1 in the Bandini area east of Los Angeles, is turning out to be a good producer. The company reported a flow at the rate of 1560 bbl. daily of clean 36 gravity oil with 3,600,000 cu. ft. of gas.

● **OKLAHOMA.** C. R. Ross, of Mt. Vernon, Illinois, has opened a new gas pool north of Wewoka with Hall No. 1, NW SE SE 3-9n-8e, Seminole County. Gilcrease sand was at 3214-40 ft., and the well tested an estimated 11,000,000 ft. of gas a day with pressure of 1150 lb.

Completion of Atlantic Refining et al No. 1 Hill in NW NW NW 25-8n-18w, discovery well near Rocky in Washita County, is expected soon. The Pennsylvanian was found at 6160 to 6236 ft. On a drillstem test at 6190 to 6231½ ft., the well gaged 13,200,000 cu. ft. of gas a day after 8 min. and increased to 15,100,000 cu. ft. for the last 10 min. of a 20-min. test. Crews are due to quit drilling at 6500 ft.

● **MISSOURI.** Word from St. Joseph indicates that Missouri may have another shallow pool. J. E. Palensky No. 1 O. O. Wallace, a wildcat in SW NW NW 10-65n-36w, 8 miles northwest of Maryville, Nodaway County, has oil showing between 2020-25 ft., total depth. The Schlumberger survey indicated the Mississippi lime encountered at 1847 ft. and a showing in a shaley lime phase.

● **TEXAS.** Grace-Grace No. 1 Dr. A. B. Edwards wildcat, Bruner survey, is a prospective pool opener for Archer County. Production is expected from a sandy lime topped at 5489 ft. Saturation showed from 5490-99 ft. and with tool open 55 min. 1700 ft. of free oil was recovered.

The apparent opening of a new Gray sand pool, 4 miles from nearest production in Northwest Coleman County, has been announced by officials of Allied Oil Company of Dallas. The well, Minnie Templeton No. 1, drilled in partnership with Fulwiler and Hughes of Abilene, topped the sand at 3457 and cored to 3486 ft., where it was still in sand. On a drillstem test at 3455 ft., the well flowed clean oil.

A new Strawn sand oil pool for Archer County is indicated by the Kadane and Collum No. 1 Jones and Collum. Bottomed at 4424 ft., the wildcat was pumping 10 bbl. of high gravity oil daily through 60 perforations in the casing from 4120-30 ft. after 2000 gal. of acid. The well showed some free oil prior to acidizing.

Stanolind Oil and Gas Company is opening a new field in Hockley County at its Veretto No. 1, 2 miles west of Levelland. The well flowed 153 bbl. of oil the first 24 hr., after acidizing lime zone at 4760 to 4842 ft. Plugback depth is 4853 ft.

Wilbarger County has a prospective Ellenburger oil discovery with W. T. Waggoner No. 1—Q. Q. Waggoner Estates, in the Waggoner "Big Pasture" district. The well was bailed to the bottom at 4650 ft., where casing had been perforated with 44 shots from 4570-80 ft. with recovery of only a slight show of oil. Casing was then perforated with 60 shots from 4500 to 4512 ft. and the wildcat swabbed 7 bbl. of oil in 5 hr.

Sterling Oil and Refining Company No. 1 J. J. Welder has opened a new gas-condensate pool in Victoria County, 7 miles east of the townsite of Nursery. Drilled to 5750 ft. operators perforated the sand section from 5690-710 ft.

A Gonzales County wildcat that is being watched is Quintana Petroleum Corporation No. 1 Anna Spahn. A test in the Cotton Valley recovered a small amount of oil. Total depth is 10,843 ft.

There are indications of a new Mississippi lime oil pool for Young County with the Davis Investment Company No. 1 Kindley. The wildcat topped the Mississippian lime at 4677 ft., and drilled lime showing oil from 4747-62 ft. with top of the Ellenburger coming in at 4820 ft. Total depth of the well is 4854 ft.

A second Smackover lime oil pool is expected for Bowie County with the testing of Barnsdall Oil Company No. 1 Pickering, wildcat 3 miles north of the Eylau Smackover field. The well topped the Smackover at 7038 ft., drilled to 7094 ft. and cemented casing at 7040 ft. It had a showing of oil just below where the casing is set.

Mills Bennett No. 1 Martha Berger opened a new gas-condenstate pool for Bee County. On a drillstem test from 8130-40 ft., the well recovered 180 ft. of condensate and 240 ft. of fresh water. Total depth is 8890 ft.

A new oil pool apparently has been opened in Rusk County, with the Delta Drilling Company No. 1 Rayford. The well was reported to have flowed 25 to 30 bbl. of oil in 24 hr., together with 2,000,000 cu. ft. of gas from the Travis Peak sand of the basal Trinity. Total depth is 7385 ft.

Young County has a new gas area with the opening of a new pool by the Republic Natural Gas Company No. 1 Rubenkoenig. A drillstem test of 45 min. was run with recovery of 950 ft. of salty gas-cut drilling mud. Production is expected from the Strawn gas section.

A new wet gas pool was opened in the coast area by the Ohio Oil No. 1 Kirby Lumber, James McCoy survey. The wildcat flowed ungaged from perforations at 9106-27 ft.

The Jay Simmons No. 1 Poehler, Fifer survey, indicates a new Goliad County pay area. The well showed condensate production in the Wilcox. A 17-min. test on perforations at 8286-89 ft. obtained a flow of wet gas with recovery of 200 ft. of condensate.

Allied Oil Company's No. 1 Lee Sanders, Shackelford County, points toward the establishment of the first Ellenburger lime pay in that immediate area. The well is bottomed at 4538 ft. and initial estimates rate it better than 100 bbl. daily.

There are prospects for a new Gunsight lime pay area in Runnels County with R. A. Gillespie No. 1 B. N. Wilke. The test at 2460-90 ft. is credited with obtaining some free oil and oil-cut mud.

● **ILLINOIS.** Illinois basin oil operators are watching with interest Gulf Refining Company's No. 1 Gale Knox, NE NE SE 4-3s-4e, about 6 miles southeast of Mt. Vernon. The Aux Vases sandstone was found from 2898 to 2923 ft. A one hour drillstem test on that zone showed gas in 26 min., 2133 ft. of free oil and 60 ft. of oil cut mud.

● **FLORIDA.** The O. D. Robinson No. 1 State, wildcat, 29-59z-40e, on the west shore near the tip of the peninsula in Florida Bay, Monroe County, may prove to be Florida's second oil discovery. Drilling dolomite from 10,160-70 ft., the well recovered live oil in the pits at 10,168 ft. and a core at 10,170-175 recovered 5 ft. of dolomitic lime with good oil stain. Another core, from 10,175-178 ft., also showed slight oil in lime. Coring continued to 10,247 ft., with oil shows.

● **KANSAS.** Butler County has a new oil pool at the Nadel and Gussman and associates No. 1 Crowley, in the SW SW SE 11-28-5e, 1½ miles north of the Fox-Bush field. Formation tests taken in the Mississippi lime at 2736 ft. indicated the well is capable of producing 100 bbl. of oil daily.

There are two pools looming for the Rooks County region, where interest is centered around two wildcats. Republic Natural Gas Company's No. 1 Cooper, in the SE SE SE 14-7-20E had good saturation in the top 4 ft. of the Arbuckle, which was found at 3498 ft. Light oil shows also were logged in the Lansing lime.

Bird and Boreing and Associates No. 1 Veverka, in the CSL. SW SW 27-8-18w, 8 miles north of production in the Webster pool, is a definite pool opener for Rooks County. With 2662 ft. of oil in the hole from the Arbuckle, at 3403-9 ft., the well swabbed 27½ bbl. of oil an hour off bottom.

Bridgeport Oil Company No. 1 Stoops, C SE SW 7-29-12w, in Pratt County opened a new gas pool. The well was abandoned by Shell Oil Company 4 years ago as a dry hole. It gaged more than 5,000,000 cu. ft. daily from the Viola lime at 4446 ft.

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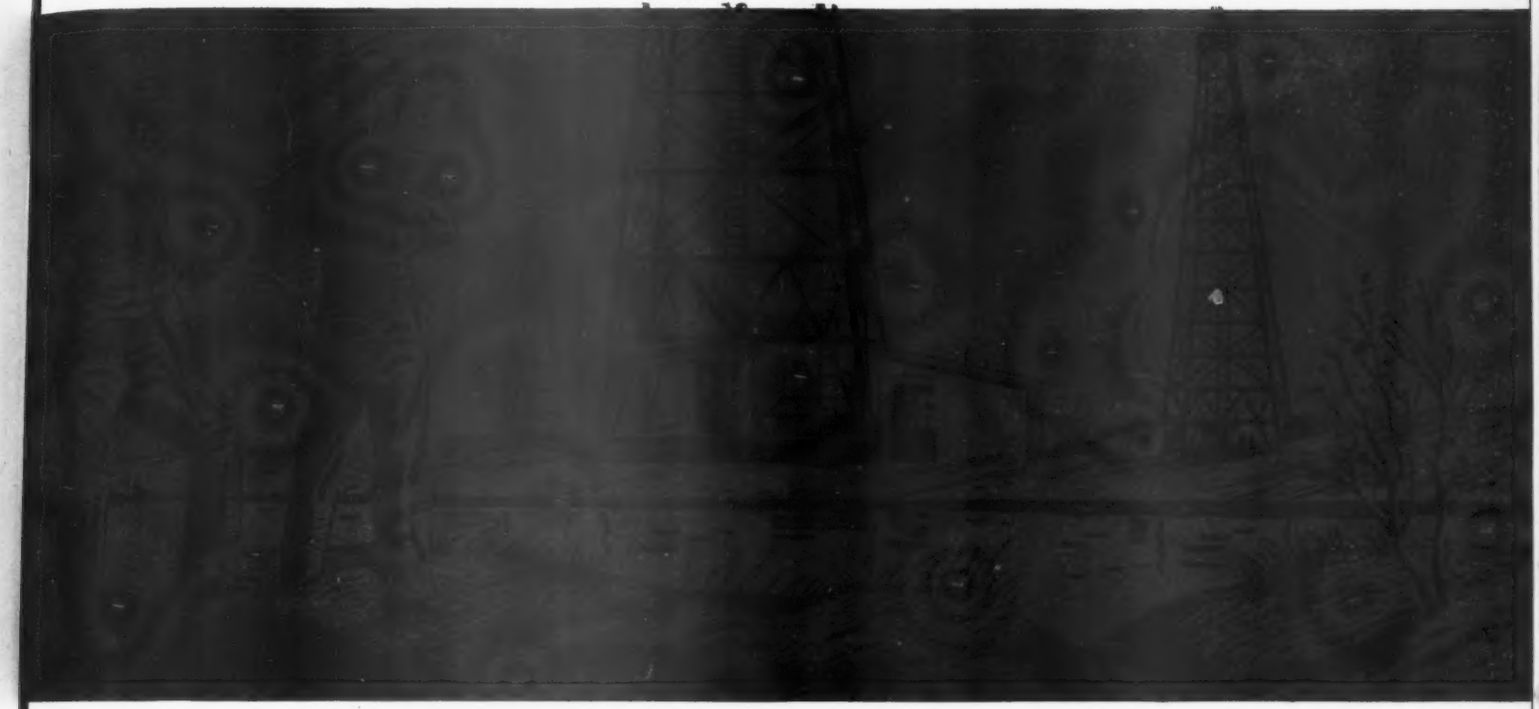

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Texas Example:

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FOR OIL INDUSTRY CHEMICAL SERVICE

MAJOR *Pipe Line* ACTIVITIES

● **NEW OUTLET.** Block 31 Devonian and Ellenburger field in east central Crane County, Texas, will have a new crude oil outlet. The Texas-New Mexico Pipe Line Company will lay 6 miles of line from its Crane station to the field.

● **EXTENSION SOUGHT.** The Tennessee Gas and Transmission Company has made application to the FPC to build a 95-mile pipe line from the San Salvador field in Hidalgo County, Texas, to the vicinity of Corpus Christi, to connect with their gas pipe line that runs to West Virginia. L. L. Tonkin, president of the Hope Natural Gas Company of Clarksburg, West Virginia, urged the delivery of more natural gas from Texas to the east and asked the commission to approve the application made by the Tennessee Gas and Transmission Company.

Proposed new facilities include: Three compressor stations in Victoria and Montgomery counties, Texas, and Natchitoches Parish, Louisiana, with a total capacity of 25,000 hp., 410 miles of main line loop at intervals along the existing 24-in. main line from Hidalgo County, Texas, to Clay County, West Virginia, and 18 new compressor units.

● **NEW PIPE LINE.** The construction of a 79-mile 14-in. pipe line is underway by the Lone Star Gas Company. The line is to tie the Carthage gas field of Panola County, East Texas, considered second largest in the world, into the company's 5000-mile network of transmission trunk lines. The new gas carrier will extend due west to the company's pipe line network at Opelika in Henderson County. From this point gas from the Carthage field will travel to Trinidad through a 12-in. carrier, then to Irving by a 20-in. trunk line, and into Fort Worth.

● **NEW LINE APPLICATIONS.** Application has been made to the FPC by the Mid-Continent Transmission Company, Wilmington, Delaware, for authority to construct and operate a 400-mile 26-in. main transmission pipe line from the Hugoton gas field near Liberal, Kansas, to Kansas City, Missouri. The application said construction would be completed by November at an estimated cost of $25,620,000.

The FPC also received an application from Cincinnati Gas Transportation Company, Charleston, West Virginia, for permission to construct and operate an additional pipe line in Kentucky to augment its capacity to meet increasing demands.

● **INCREASE LINE CAPACITY.** The capacity of Magnolia Pipe Line Company's 12-in., 337-mile trunk carrier from Midland to Corsicana has been increased from 57,000 to 66,000 bbl. The installation of new pumping units along the line has provided the extra capacity. Demand for West Texas Permian Basin crude oil has been bottlenecked in the burning oil season because of lack of capacity to handle the crude needed at Gulf Coast refining centers, despite the fact line capacity is the highest in history.

● **SURPLUS CASING USED.** The White Eagle division of Socony-Vacuum Oil Company will use 8-in. casing acquired from the U. S. Surplus Property Office on their 32 miles of 8-in. pipe line from the Morrel pool of Graham County, northwestern Kansas, to the Bemis station on the Kaw Pipe Line Company artery. The casing was originally intended to be used in making bomb shell cases. Rumsey Brothers of Wichita has the contract to string and lay the line.

The Kansas Corporation Commission was to resume a hearing this week on the application for construction of the line. Protesting the proposal are Merrimac Oil Company and the Farmers Cooperative Oil Company.

● **SEEKS CONTROL OF LINE.** The Union Gas System, Inc., with offices at Independence, Kansas, has made application to the FPC for permission to acquire and operate a small gas pipe line system in the vicinity of Coffeyville, Kansas. The Independent Industrial Gas Company and the Veeder Supply and Development Company own and operate the system at present. The purchase contract would be effective as of January 1, 1946, and the agreed price is $150,000.

The pipe line facilities are adjacent to Union's present facilities and consist of lines extending north and east from Coffeyville. Gas is distributed from these lines to local distribution plants in Altamont, Galesburg, Fall River, Mound Valley, Angola, Morehead, and McCune, Kansas, and to a few industrial users in Coffeyville.

● **PLAN ADDITIONAL FACILITIES.** Northern Natural Gas Company has made 6 applications to the FPC to construct additional facilities in Iowa, Kansas, and Nebraska, and to operate existing facilities to sell gas for retail distribution.

The applications seek authority to construct the following facilities: (1) Construction of a 450-hp. gas compressor station near Otis, Kansas, and a 2400-hp. compressor station near Cherokee, Iowa. (2) Installation of two 1000-hp. compressor units at the Sublette, Kansas, station; a 900-hp. compressor unit at the Oakland, Iowa, station, and an 800-hp. compressor unit at the South Sioux City, Nebraska, compressor station. (3) Construction of about 156 miles of 24-in. loop line, about 11½ miles of 20-in. loop line, about 40 miles of 18-in. loop line, and about 6½ miles of 12¾-in. line, the last to connect the South St. Paul and the St. Paul town border stations. The various loop lines will effect a double pipe line system between compressor stations and thus increase the capacity of the present lines. (4) Construction of a number of small-diameter lines to Webster City, Madrid, Granger, and Grimes, Iowa; Bell Plaine, Jordan, Janesville, and Dunnell, Minnesota, and Murdock, Nebraska, to enable Northern Natural to supply gas at wholesale for retail distribution in these areas. (5) Construction of a 2-in. side valve connection with necessary appurtenances on the 18-in. gas transmission line as well as a measuring and regulating station in the vicinity of Mynard, Nebraska.

● **APPROVE LINE CONSTRUCTION.** The California Railroad Commission has approved the construction of 214 miles of 26-in. gas line from Santa Fe Springs to Blythe on the California-Arizona border. This line, a joint venture by Southern California Gas Company and Southern Counties Gas Company, will tie into the 720-mile pipe line from Texas, to be built by the El Paso Natural Gas Company. Application to the FPC for authority to operate the line has already been made by the three gas companies involved. Capital cost of the California section of the line with incidental facilities is estimated at $12,400,000 and another $3,000,000 approximately will be required for the compressor plant to bring the project up to an ultimate capacity of 305,000,000 cu. ft. a day. It is expected that for the first five years, the line will handle 175,000,000 cu. ft. a day.

The Phillips Petroleum Company of Texas has presented the FPC with arguments in favor of the proposed Texas-California gas pipe line.

● **OKLAHOMA OUTLET.** Kerr-McGee Oil Industries, Inc., and Fen-Ter Refining Company have announced the construction of a 6-in. pipe line from the Fen-Ter plant at Wynnewood, Oklahoma, to the new North Davis field in Garvin County, Oklahoma. The oil line will be paralleled by a gas line, on which will be installed heaters to permit free flow of the 13-gravity crude oil.

● **WEST TEXAS LINE.** Stanolind Pipe Line Company will construct 35 miles of 16-in. pipe line to extend its West Texas-Drumright, Oklahoma, 16-in. trunk line from Sundown station in the Hockley County sector of the Slaughter field to the Wasson field. The entry of Stanolind into the Wasson area with a 16-in. line paves the way for the early extension of its carrier to the Fullerton and other sweet crude areas in Andrews County, where Stanolind Oil and Gas Company is a substantial producer. It is planned to begin the construction work in May.

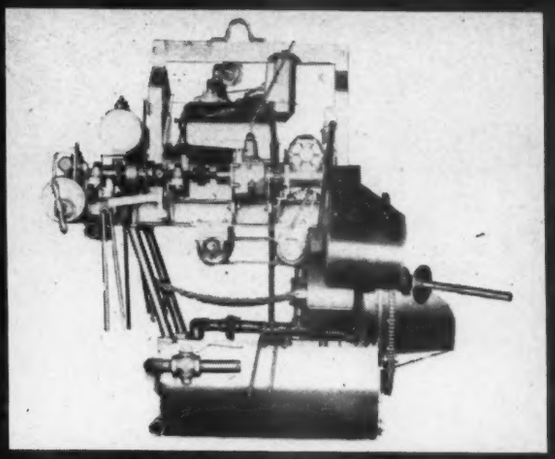
Overseas Assignment . . .

Perrault Brothers are "pointing with pride" at the new assignment they have just received from the Iraq Petroleum Company . . . Perrault will supply all of the Cleaning and Priming machines and Coating and Wrapping machines to be used on approximately 1240 miles of 12¾" OD reconditioned pipe and 1240 miles of 16" OD pipe for new construction . . . the largest project ever to be awarded a concern supplying this type of equipment. To the Iraq Petroleum Company and its affiliate the Standard Oil Company of New Jersey, goes deep appreciation for the confidence they have shown in Perrault Brothers' ability to provide superior equipment on such a large scale.

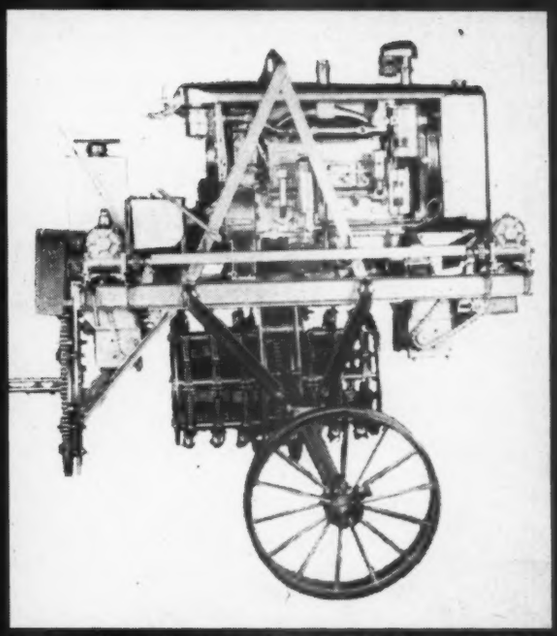
Lewis Perrault

Ainslie Perrault

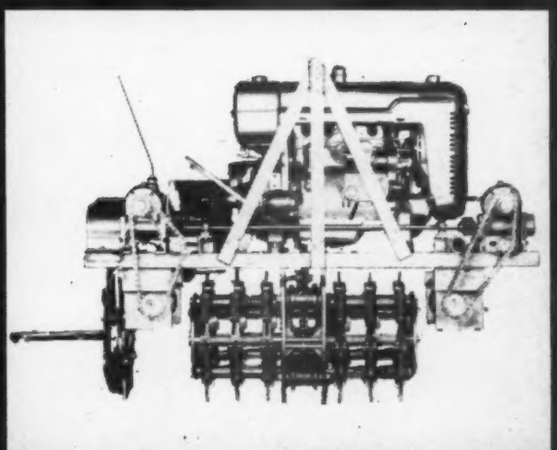
M. J. (Whitey) Crose



Line traveling, combination Coating and Wrapping Machine, with the new, trouble-free coating shoe (patent applied for), self-aligning, independently adjustable in each segment with no spacers in contact with pipe!



Line traveling, Cleaning and Priming Machine with D3400 Caterpillar Diesel Engine, special for Iraq project with cleaning and priming head for 12"-16" pipe inclusively.



Line traveling, Cleaning and Priming Machine for 3"-7" pipe. Powered with U2 International Gasoline Engine. Others in sizes 8"-14", 16"-20", 20"-24" and 26"-28".

(Actual photographs . . . Not retouched)

Brothers

PIPELINE SUPPLIES

1130 NORTH BOSTON • TULSA 6, OKLAHOMA • TELEPHONE 5-1104

MAJOR *Refining* ACTIVITIES

● **PLANT FORMALLY OPENED.** The gasoline absorption plant at Winnie, Texas, was formally opened on March 6, by Glenn H. McCarthy, Houston independent oil operator. The plant has a capacity of 85,000,000 cu. ft. of gas daily, including 30,000,000 cu. ft. of casinghead, or low pressure gas, and 55,000,000 cu. ft. of high pressure gas from gas and gas-condensate wells. The plant is fed by a gathering system that connects with virtually all the producing pools in the area ranging from the Fig Ridge pool, 9 miles south of the plant, to Fannett, 4 miles to the east. The 30,000,000 cu. ft. of casinghead gas daily that is now going to the plant was flared previous to construction of the plant. The gas now is utilized to provide natural gas for the lines of the Jefferson Pipe Line Company, an affiliated McCarthy company. The gas produced by the gathering system is in addition to 40,000 gal. of liquid products processed daily. The gas is taken from 182 oil and gas wells on 85 leases in the area.

Features of the plant include a large compressor house that contains ten 800-hp. compressors, 2 large stationary boilers, 2 stills, high and low pressure absorbers and vents, and 5 large towers for extracting isopentane, isobutane, butane, propane, and ethane.

● **NAVY RETURNS REFINERIES.** The Navy has returned the following plants to their managements: Pure Oil Company, Smith's Bluff, Texas; Magnolia Refining Corporation, Beaumont, Texas; Elk Refining Company, Falling Rock, West Virginia; Ashland Oil and Refining Company, Catlettsburg, Kentucky; Atlantic Refining Company, Atreco, Texas; Union Oil Company of California, Oleum and Wilmington, California; Petroleum Specialties, Inc., Flat Rock, Michigan; Republic Oil and Refining Company, Texas City, Texas; The Texas Company, Lawrenceville, Illinois; Standard Oil Company of Ohio, Cleveland; and The National Refining Company, Findlay, Ohio.

● **REFINERIES FOR SALE OR LEASE.** Six oil refineries with an aggregate daily production capacity of 24,625 bbl. of 100-octane aviation gasoline and 6500 bbl. of other grades have been offered for sale or lease by the War Assets Corporation. The operators, location, and daily capacity of the plants, all of which were built during the war, are as follows: Utah Oil Refining Company, Salt Lake City, and Ft. Laramie, Wyoming, 5500 bbl. of 100-octane gasoline; Root Petroleum Corporation, El Dorado, Arkansas, 1900 bbl. of 100-octane; Frontier Refining Corporation, Cheyenne, Wyoming, 1650 bbl. of 100-octane, 1300 bbl. of motor gasoline; Ashland Oil and Refining Company, Catlettsburg, Kentucky, 5300 bbl. of 100-octane; J. S. Abercrombie Company and Harrison Oil Company, Sweeny and Freeport, Texas, 8500 bbl. of 100-octane, 3500 bbl. of army all-purpose gasoline, and 1700 bbl. of 91-octane; The Pennzoil Company, Oil City, Pennsylvania, 1685 bbl. of 100-octane.

● **RELEASE OPTION.** Associated Refineries, Inc., has released the option it held to purchase the $14,398,000 refinery at Duncan, Oklahoma, now offered for sale or lease by the War Assets Corporation. Companies that constituted Associated Refineries, Inc., and supplied products to it for the manufacture of 100-octane gasoline are Anderson-Prichard, Bell Oil and Gas Company, Ben Franklin Refining Company, Fen-Ter Refining Company, La Salle Petroleum Company, Rock Island Refining Company, Panhandle Refining Company, and Waggoner Refining Company.

● **CYCLING PLANT.** Lone Star Gas Company has begun construction of a cycling plant 8 miles north of Carthage, Texas. The plant will be jointly owned by the Lone Star Company and Rogers Lacy of Longview, Texas. It will have a capacity of 50,000,000 cu. ft. of gas daily for cycling purposes and a further capacity on initial installation of an additional 50,000,000 cu. ft. daily for pipe line delivery of gas.

The Carthage plant will make motor fuel, butane, kerosine and fuel oil. The company's plant at Willow Springs, Gregg County, East Texas, is being dismantled to provide equipment for the Carthage plant. The Lone Star company will build another gasoline plant in the Chapel Hill pool of eastern Smith County, East Texas, which it will own jointly with the Shell Oil Company, Inc.

● **RESEARCH LABORATORY.** Plans for the construction of a petroleum research laboratory at Harvey, Illinois, have been announced by the Sinclair Refining Company. The project will provide enlarged quarters for laboratories now situated at East Chicago. Work in the laboratories will be expanded to include further uses of petroleum in the fields of plastics, rubber, medicine, household conveniences, and will accelerate many of the wartime developments of fuels and lubricants for civilian usage.

● **STANDARD LABORATORY.** Standard Oil Company of Indiana's petroleum research laboratories at Hammond, Indiana, are now under construction. Upon completion they will house 420 chemists, chemical engineers, and other scientists, along with 800 technicians and other assistants. Scheduled for completion in the initial part of the construction are the administration and chemical engineering building, the main research laboratories, and the pilot plant buildings equipped for work on greases, catalysts, and chemicals. The new laboratories will be ready for occupancy early in 1947.

● **PURCHASE REFINERY.** Continental Oil Company has purchased the refinery at Artesia, New Mexico, of Malco Refineries, Inc., it was announced by Dr. Walter Miller, vice president in charge of manufacturing. Continental Oil Company has for many years owned and operated a refinery in Artesia, adjacent to the Malco plant. The two plants will now be consolidated and operated as one refinery, it was said.

"The combined Continental and Malco refineries will have a total daily crude charging capacity of 2500 bbl.", Dr. Miller stated. Crude for the operation is from New Mexico oil fields.

● **"WASTE" GAS PLANTS.** It has been announced by Stuart E. Buckley, head of the Humble production department, that Humble Oil and Refining Company and associates will spend $8,000,000 in the next 2 years in construction of plants to process waste gas in 10 fields of the Texas Gulf Coast. Buckley said most of the construction will be in the Houston area and is planned to process virtually all the flared gas in that district. Residue from the plants will be turned to intrastate distributors, he said.

● **OIL PLANT BOUGHT.** The Nebraska Producing and Refining Company refinery and properties at Salem, Nebraska, have been purchased jointly by J. R. Watt, Tulsa Iron and Metal Company, Meyer Moran, Moran Oil Company, A. M. Stekoll of Tulsa Supply Company, all of Tulsa, Oklahoma, and John Peters of Salem. They announce that steps are being taken to reorganize the firm as the Oil Marketing and Refining, Inc., of Salem, and they plan to market their tractor fuel, diesel fuel, kerosine, and other by-products from Nebraska crude oil in Nebraska, Iowa, and adjacent states.

● **PLAN CATALYTIC CRACKING UNITS.** Plans for construction of a 4500-bbl. daily catalytic cracking unit at El Dorado, Arkansas, have been announced by officials of the Lion Oil Company. The announcement said the plant would be for the manufacture of gasoline, furnace oils, and other products and would embody latest refining developments.

Aurora Gasoline Company of Detroit has announced that the company has signed a license agreement with Universal Oil Products Company of Chicago for the installation of a UOP improved fluid catalytic cracking unit, with design charge of 4000 bbl. a day. Aurora becomes the first refining company to proceed with the installation of the improved design UOP fluid catalytic cracking unit incorporating the latest techniques, according to a statement by Max Fisher, vice president.

THE Petroleum Engineer
MARCH, 1946

WHY WELL TESTS MUST BE MADE ACCURATELY

K. MARSHALL FAGIN, *Field Editor*

ALL the things that we know about a producing well, an oil producing property, or an oil field stems from the records of tests of individual wells. Even the routine daily production of oil, gas, and water from a well is, in effect, a continuous test or measure of the well's producing ability and producing characteristics. The only way, then, that we can improve our knowledge and verify our opinions of oil wells, oil properties, and oil fields, is by seeing to it that these tests are accurately taken and that the conditions under which the tests are made are carefully recorded.

EXCLUSIVE

Inasmuch as most important oil wells are being "brought in" under controlled conditions and are being operated at reduced rates of production, it is more important than ever for the operators to insist that all the tests, required or voluntary, be taken accurately and carefully and filed so that the data will be available for future reference. Unless that is done, the operators themselves will not be able to make satisfactory or reliable judgments of the wells, the properties, or the fields.

● **Important decisions require test data.** Opinions and decisions concerning today's controlled wells are derived from the basic facts measured and observed during the various tests that are made of the wells. The following calculations and estimations form important parts of these opinions and large errors of judgment may be made, if the basic facts are wrong, or if some of them have to be estimated:

1. Calculation of the per well allowable.
2. Calculation of the optimum producing rate of the well, and of the field as a whole.
3. Calculation of the mechanical efficiency of the well as a producing unit.
4. Calculation of the exploitation efficiency of the wells in the field as a whole.
5. Estimation of the future production (reserve) of the well, the property, and the field.
6. Estimation of the value (present worth) of the well, property, and field.
7. Estimation of the value (present worth) of working over, drilling deeper, plugging back, plugging off, shooting, or acidizing the present wells in a field.
8. Estimation of the additional future production that would be expected by:
   a. A gas pressure maintenance project.
   b. A water pressure maintenance project.
   c. A combination gas and water pressure maintenance project.
   d. The drilling of additional wells.
   e. The application of a secondary recovery project.

Well tests supply basic information needed to determine courses of action to increase recovery.

K. M. Fagin

● **Basic facts need to be ascertained and recorded carefully.** It is a relatively easy thing to form opinions of the feasibility of spending the money necessary to increase the yield of oil from the earth, if the basic facts observed during the individual well tests have been measured accurately and recorded carefully, inasmuch as the methods of calculating the quantities of additional production are usually much more exact than the basic information available. Evidence of this is the fact that differences in the opinions of various operators in a certain field, for example, are usually based upon differences in the basic facts available to them, and, as soon as the operators agree on the basic facts, they usually agree on the conclusions that may be calculated or estimated therefrom.

● **Basic facts are established by many tests.** There are many kinds of well tests that reveal some basic facts about the

producing formations and the conditions of the wells. These tests may be listed in the order in which they are taken as follows:

1. Coring tests and core analysis.
2. Drillstem tests.
3. Electric logging.
4. Radioactivity logging.
5. Caliper logging.
6. "Straight hole" tests.
7. Pressure test of casing.
8. Temperature survey for cementing test.
9. Initial production (potential) test.
10. Initial bottom-hole pressure and temperature test.
11. Periodic gas-oil ratio tests.
12. Periodic potential tests.
13. Periodic water-oil ratio or "shake-out" tests.
14. Periodic bottom-hole pressure tests.
15. Periodic production efficiency or productivity index tests.
16. Bottom-hole fluid sampling tests and analysis.
17. Periodic wellhead pressure tests.

● **Tests are not always comparable.** One of the most important things to keep in mind about many of the tests listed above and the other tests that may be made is the fact that the results of the tests are not comparable from field to field, or even from well to well in many cases. This is especially true in the case of the initial production test.

The so-called initial production or potential of a well is often just a nominal figure obtained during a short flow or pumping test to prove that a well can make its allowable. In other instances, it is the product of the quantity of oil made during a short test multiplied by a factor to indicate the quantity the well would make during a 24-hr. period, if it continued to produce at the short-time rate.

In some fields, state regulations may specify the size of the choke to be used on a flowing well's potential, or the size of the pump to be used on a pumping well. The initial potential of wells in other fields may be taken by draw-down or productivity index tests. It is important, therefore, to know the conditions of the tests, and to know how well the rules have been observed, before attempting to compare the results of the tests from different wells.

● **Preparation of wells for tests important.** Many of the various kinds of well tests require careful preliminary preparation of the hole, the drilling mud, the tools, the instruments, the pumps, the flow or lead line systems, the separators, the tanks, and the well. Certain tests, as most operators know, will result in erroneous basic facts, if these pre-test rules or customs are not carefully observed. It follows that the rules or customs should be meticulously and regularly heeded, in order to make the results (basic facts) comparable.

Coring tests in many oil fields provide the most important basic facts about the reservoir formation and its contents. In other oil fields, the customary coring technique is handicapped by the softness or fragile nature of the formation, and relatively little basic information can be obtained from analysis of the fragments that are recovered. The preliminary preparations for coring are usually a matter of custom and of trial and error. Successful coring (sampling of the producing formation) requires the use of considerable personal judgment based on experience in coring similar formations.

Drillstem testing, electrical and radioactivity logging, caliper logging, straight hole (deviation) testing, pressure testing of casing, and temperature surveying to check cementing jobs require careful preparations, in order to obtain satisfactory results. The drilling mud, for example, should be checked and conditioned prior to running an electric logging test. The presence of salt water in the lower portion of the hole, for instance, would affect the results considerably and might cause an oil or gas sand to be overlooked.

● **Records of test data should be complete.** Probably the most important preliminary precaution in making any test of a well is to be sure that all customary practices are observed and promptly noted on the test records. Nothing is more important at a later date than a clear, concise, and complete record of all the conditions and procedures followed during any test of a well. These records should contain all the pertinent and basic facts determined by the test.

The initial production or potential test is probably one of the most important tests that is made of a well, especially in those fields where a well's allowable is calculated from the results obtained. In such fields the tests are usually conducted according to a set of rules prescribed by the regulatory authorities of the state after formal hearings or conferences with the operators in the field or area. Such tests are usually witnessed either by an employe of the regulatory commission or an offset operator. It is obvious to those that are familiar with the various sets of rules for taking these initial production tests that the results (the potentials) are at best only a relative measure of the true producing capacities of the wells in a field.

● **Potential tests affect allowables in many fields.** Every operator in such a field is or should be alert to the fact that every preparation for such a test should be made with an eye to obtaining the highest possible potential rating that the particular set of rules will allow. This means that the well will be thoroughly cleaned out and in the best possible shape for the performance test. Here, again, the record of the conditions of the test will have more value at a later date than the test itself.

The initial production test used to be simply a record of the first 24 hr. production of oil, gas, and water from a new well, and was entered in the drilling record of the well. That is about all that it amounts to on small or "unprorated" wells being completed at this time; but regardless of the method, purpose, or time of taking this test, the basic facts are worthwhile keeping in complete detail for use as a basis of comparison with later tests throughout a well's productive life.

● **Pressure tests require preparation.** Preparations for taking the initial and periodic bottom-hole (reservoir) pressure and temperature surveys are important and similar. The wells should be clean and in good producing condition. The tubing should be cross-barred or bull-plugged at the bottom and should extend to the top of the producing formation. The wellhead should be equipped with a satisfactory lubricator, and the well should be kept positively closed in for a fixed period of time prior to the test.

In some fields recording pressure gages are being used to check the observance of the shutin period. Otherwise, the tests will not reveal the static reservoir pressure that is so important in determining the presence or absence of a water drive, and later tests will not be readily comparable to the initial tests, if the conditions of the tests are not uniform.

● **Tests properly conducted supply sound basis for action.** The basic facts derived from bottom-hole pressure, gas-oil ratio, productivity index, bottom-hole fluid sample, and coring tests form the most important foundations on which to base opinions of individual well and reservoir performance, and on which to draw conclusions regarding the feasibility of individual well remedial work or fieldwide pressure maintenance or secondary recovery work. The basic facts, then, together with all pertinent conditions, are worth getting and recording properly and uniformly in order to tell what, if any, action should be taken to improve or remedy the producing characteristics of individual wells or fields.

Improvements are constantly being made in the technique of testing individual wells, and better instruments and facilities are being designed and provided for the use of the operators. Many of these testing devices may be too expensive for small operators to purchase, but the basic facts that can be determined by the devices are usually so important that it pays the small operators to purchase them jointly with others, or to arrange for the tests to be conducted by specialists that are equipped with the proper facilities. ★ ★ ★

Flare gas plants

Two major oil companies are planning construction of absorption type plants in the Gulf Coast area in an effort to conserve millions of feet of casinghead gas now being flared in Texas fields. Humble Oil and Refining Company plans to spend $4,872,000 on a plant with a capacity of 60,000,000 cu. ft. of gas. A $4,000,000 plant is also planned by Stanolind Oil and Gas Company.

Oil tank and simulated deck-house fires being put out with foam.

Petroleum Engineer Picture Story

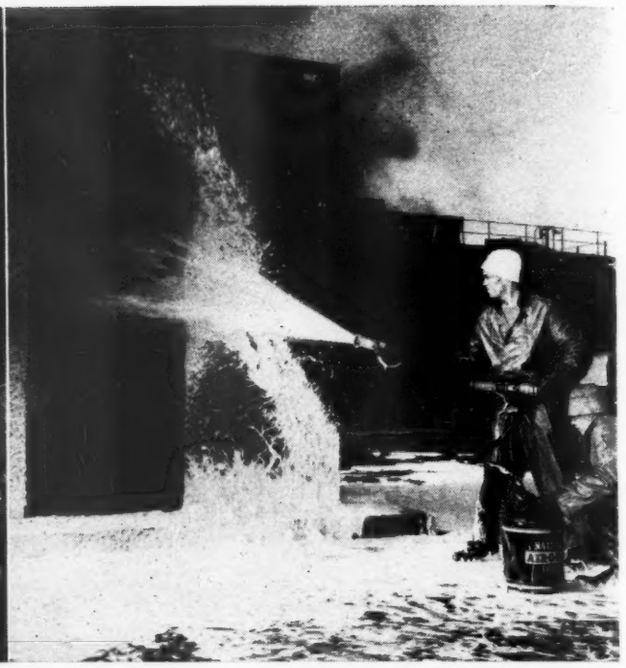
NAVY SHOWS HOW TO FIGHT FIRE

FIRE is dangerous anywhere at any time, but fire at sea requires exceptionally fast, sure means to put it out. The U. S. Navy, fighting a far-flung war, carrying highly inflammable goods, subject to sudden attack and, therefore, to sudden, raging fire, had to have effective fire smothering equipment, much of which was foam. The Navy promptly dubbed it "bean soup" because its manufacturer, National Foam System, Philadelphia, Pennsylvania, uses soy beans in producing the foam.

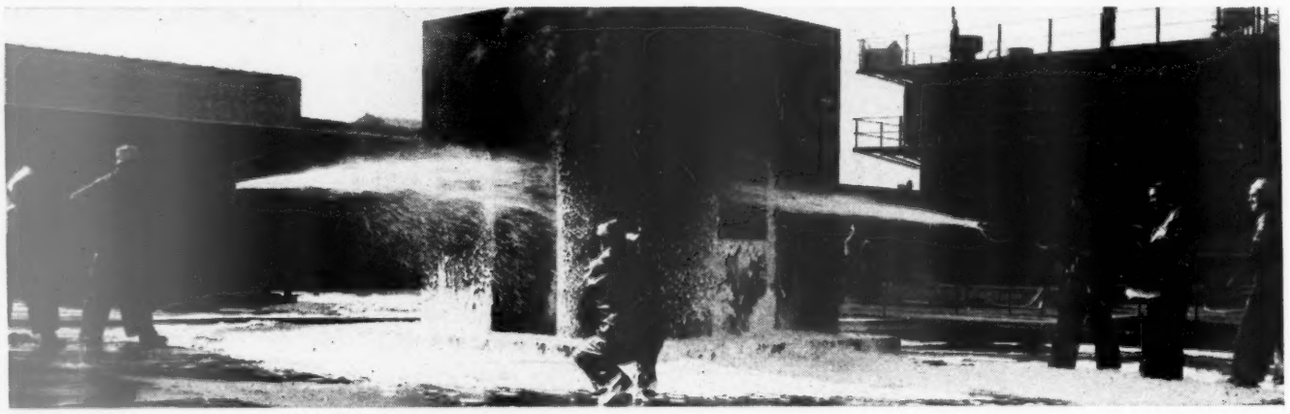
Private industry is getting the benefit of what the Navy learned in fighting fire. Fire-fighting schools, such as the one at the Brooklyn Navy Yard, turned out many efficient "smoke-eaters" and their work is now in the "now it can be told" stage. Proved methods of fighting fire quickly and

Extremely hot oil fire being smothered by foam mixture of 6 per cent (note cans held by men) and water comprising 94 per cent of stream. One or two men can easily handle such fire-fighting equipment. The operator takes a hose, equipped with a special nozzle, through which fresh or salt water is pumped in the ordinary way. Another smaller, shorter hose is screwed into the larger one near its nozzle, with the other end of the small hose dipped into a can of foam liquid. Water being forced through the larger hose sucks up the specially concentrated "soup" and, through a special aperture, also draws in air. When these combine, a heavy, whipped-cream looking chemical gushes forth to form a blanket that separates the flames from the fuel they feed on, seals in gases and excludes oxygen. All photos were made at Brooklyn Navy Yard fire-fighting school.

Foam extinguishing fire under plates in "bilge." Shot made on simulated destroyer deck structure. Navy class looking on.



Fire-fighting team putting out oil fire in simulated deck-house. Foam clings to upright surfaces, insulating it against flames.



Two Navy teams putting out high-octane gasoline fire with foam. Below, left—Technique of putting out fire by applying foam against bulkhead, rather than directly into the fire is demonstrated.

effectively with foam, now available to American business, are proving of keen interest to industry in reducing destruction by fire.

In the accompanying photos, which were made with Navy approval to demonstrate to business and industry how the fleet successfully fights fire, pressure at the nozzles is 125 lb. per sq. in. and 532 gal. of water and foam are discharged per minute. This special thick, tough, clinging foam is 94 per cent water and only 6 per cent "bean soup." One to 1½ min. are required to extinguish most fires when foam is employed. ★ ★ ★

HYDROCARBON THERMODYNAMICS*

By **WAYNE C. EDMISTER,**** Foster Wheeler Corporation

PART I

● **Introduction.** Practically all operations in hydrocarbon production, transportation, processing, and consumption involve the conversion of energy from one form to another and, of course, some energy is always lost to the low-temperature heat sink, which may be the flue gas stack, the cooling water, the atmosphere, etc. It is obvious that thermodynamics is of paramount importance to technical men concerned with these operations.

Wayne C. Edmister

The objective of this paper is to summarize the fundamental concepts of thermodynamics, to review some of the important contributions made in the applications of thermodynamics to hydrocarbons, and to outline the plan or pattern followed in developing thermodynamic tools for hydrocarbons. This discussion begins with the fundamental equations and stops with the procedure for developing working charts and tables. The development of these equations and the preparation of complete working charts and tables are outside the scope of this paper.

Thermodynamics is a natural science that deals with energy and the transformation of energy and with equilibrium and the equilibrium distribution of products. The language of thermodynamics is mathematics. A thorough knowledge of these mathematical methods is essential to an understanding of the development of the fundamental equations. Some familiarity with this mathematics is necessary to apply these equations to the preparation of charts and tables of thermodynamic properties.

For many years thermodynamics has been a very useful tool in the design and operation of steam boilers, engines and turbines, of internal-combustion engines, of refrigeration units, and of heating and ventilating equipment. Until recent years, however, very little effort has been made to apply thermodynamics to chemical and chemical engineering problems that are encountered in the processing of petroleum hydrocarbons. There are two reasons why the development of this branch of thermodynamics has lagged behind the development of the so-called engineering thermodynamics; namely, (1) mechanical engineering problems have been more pressing due to the harnessing of the recently invented steam engine, turbine and internal-combustion engine, and (2) chemical and chemical engineering thermodynamics is complicated by varying compositions of the working fluid, hydrocarbon mixtures and petroleum fractions offering some very troubling problems. Progress in the solution of these problems has been rapid during recent years so that new equipment can now be designed without too much "thermo" guessing. Many thermodynamic applications are necessary to keep process de-

TABLE 1—(Reference 7.) All references will be found at end of last article in series.

FUNDAMENTAL CONCEPTS OF THERMODYNAMICS

FIRST LAW - CONSERVATION OF ENERGY

$\Delta E = Q - W$; ΔE = CHANGE IN INTERNAL ENERGY OF SYSTEM

Q = HEAT ABSORBED BY SYSTEM

W = WORK DONE BY SYSTEM = $\int P dV$ FOR BATCH PROCESS, $\int V dP$ FOR FLOW PROCESS

$H = E + PV$; DEFINITION OF ENTHALPY

$\Delta H = \Delta E + \Delta(PV)$; $\Delta(PV) = \int P dV - \int V dP$ = FLOW WORK

SECOND LAW - DEGRADATION OF ENERGY

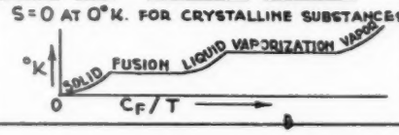
ENTROPY $S = Q/T$; OR INFINITESMALLY $ds = dq/T$

$$\left(\frac{\partial S}{\partial T}\right)_V = \frac{C_v}{T} \quad ; \quad \left(\frac{\partial S}{\partial T}\right)_P = \frac{C_p}{T}$$

$$dS = \frac{C_p}{T} dT - \left(\frac{\partial V}{\partial T}\right)_P dP$$

THIRD LAW - ABSOLUTE ENTROPY

$S = 0$ AT $0°K$. FOR CRYSTALLINE SUBSTANCES



SPECIFIC HEATS

$$C_p = \left(\frac{\partial H}{\partial T}\right)_P \qquad C_v = \left(\frac{\partial E}{\partial T}\right)_V$$

$$\left(\frac{\partial C_p}{\partial P}\right)_T = -T\left(\frac{\partial^2 V}{\partial T^2}\right)_P ; \left(\frac{\partial C_v}{\partial V}\right)_T = T\left(\frac{\partial^2 P}{\partial T^2}\right)_V$$

$$C_p - C_v = -T\,\frac{\left(\partial V/\partial T\right)_P^2}{\left(\partial V/\partial P\right)_T}$$

JOULE-THOMSON COEFFICIENT

$$\mu = \left(\frac{\partial T}{\partial P}\right)_H = \frac{T\left(\partial V/\partial T\right)_P - V}{\mu C_p = -\left(\frac{\partial H}{\partial P}\right)_T = \left[T\left(\frac{\partial V}{\partial T}\right)_P - V\right]}$$

CARNOT CYCLE

POWER: $\frac{W}{Q_2} = \frac{T_2 - T_1}{T_2}$ REFRIG: $\frac{W}{Q_1} = \frac{T_2 - T_1}{T_1}$

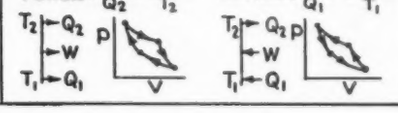


TABLE 2—(Reference 7.)

THERMODYNAMIC POTENTIALS

POTENTIAL	SYMBOL	MATHEMATICAL DEFINITIONS	INDEP'T VARIABLES	DIFFERENTIAL EQUATIONS	
				BASIC	TRANSFORMED
RESIDUAL WORK (HELMHOLTZ FREE ENERGY)	A	$A = F - PV$ $A = E - TS$	V,T	$dA = -PdV - SdT$	
FREE ENERGY (GIBBS FREE ENERGY)	F	$F = A + PV$ $F = H - TS$	P,T	$dF = +VdP - SdT$	
INTERNAL ENERGY	E	$E = A + TS$ $E = H - PV$	V,T	$dE = -PdV + TdS$	$dE = C_v dT + \left[T\left(\frac{\partial P}{\partial T}\right)_V - P\right]dV$
ENTHALPY	H	$H = A + TS + PV$ $H = F + TS$ $H = E + PV$	P,T	$dH = +VdP + TdS$	$dH = C_p dT + \left[V - T\left(\frac{\partial V}{\partial T}\right)_P\right]dP$

*Presented before California Natural Gasoline Association, Los Angeles, November 1, 1945.

**The author has been actively working in the field of hydrocarbon thermodynamics since college days at Oklahoma A. and M., where he wrote his first article on this subject in 1930. Graduate studies in this field have been pursued at Cornell University, The University of Chicago, and Illinois Institute of Technology. Edmister's industrial experience includes: (1) design, construction and operation of gas-lift and natural gasoline plants, (2) refinery process development, design and operation at the Whiting refinery of Standard Oil of Indiana, (3) operation of government synthetic rubber plants with Rubber Reserve in Washington, and (4) process design of petroleum refining plants at Foster Wheeler Corporation in New York.

GENERALIZED THERMODYNAMIC EQUATIONS

REDUCED EQUATION OF STATE

$$\frac{V}{\alpha_c} = \frac{RT_c}{P_c\alpha_c}\frac{T_r}{P_r} - \alpha_r$$

SPECIFIC HEATS

$$\left(\frac{\partial C_p}{\partial P_r}\right)_{T_r} = \frac{P_c\alpha_c}{T_c} T_r \left(\frac{\partial^2 \alpha_r}{\partial T_r^2}\right)_{P_r}$$

$$\frac{\Delta C_p}{K_2} = \int_0^{P_r} \left(\frac{\partial^2 \alpha_r}{\partial T_r^2}\right)_{P_r} dP_r$$

$$C_p - C_v = -T \frac{\left[\frac{R}{P} - \frac{\alpha_c}{T_c}\left(\frac{\partial \alpha_r}{\partial T_r}\right)_{P_r}\right]^2}{\left[\frac{RT}{P^2} + \frac{\alpha_c}{T_c}\left(\frac{\partial \alpha_r}{\partial P_r}\right)_{T_r}\right]}$$

FUGACITY

$$-\frac{RT_c}{P_c\alpha_c} = \ln\frac{f}{P} = \frac{1}{T_r}\int_0^{P_r} \alpha_r \, dP_r$$

ENTHALPY

$$dH = C_p\,dT - P_c\alpha_c\left[\alpha_r - T_r\left(\frac{\partial \alpha_r}{\partial T_r}\right)_{P_r}\right] dP_r$$

$$\frac{\Delta H}{K_3} = \int_0^{P_r}\left[\alpha_r - T_r\left(\frac{\partial \alpha_r}{\partial T_r}\right)_{P_r}\right] dP_r$$

ENTROPY

$$dS = \frac{C_p}{T}\,dT - \frac{R}{P}\,dP + \frac{P_c\alpha_c}{T_c}\left(\frac{\partial \alpha_r}{\partial T_r}\right)_{P_r} dP_r$$

$$S = C_p \ln T - R \ln P - \Delta S'$$

$$\frac{\Delta S'}{K_2} = \int_0^{P_r}\left(\frac{\partial \alpha_r}{\partial T_r}\right)_{P_r} dP_r$$

TABLE 3—(Reference 6.)

sign technique apace with the development of new refining processes.

Process design of hydrocarbon processing equipment involves: *Heat balances, material balances, equilibrium,* and *rates of reaction or transfer.* Thermodynamics is of immeasurable value in making the heat balance and equilibrium calculations, which may be divided into the following five types of process applications of thermodynamics: (1) *Combustion,* including furnaces and regeneration cycles; (2) *heat balances* including vaporization, condensation, distillation, and heats of reaction; (3) *power,* including pumping, condensation, steam and electric drives, and flue gas turbines; (4) *phase equilibria* for ideal and non-ideal solutions, and (5) *chemical reaction equilibrium,* involving estimation of equilibrium conditions and yields for reactions.

In general, the same procedure is followed in each of the above groups of application. First, experimental data are obtained and correlated, second, tabulations and charts are derived and thermodynamic properties are developed. Third, the correlated experimental and derived thermodynamic properties are applied to the problem.

The application of thermodynamics to physical process operations such as fluid flow, heat transmission, distillation, etc., involve changes in heat or work and phase equilibrium, for which fugacities, entropies and enthalpies for liquids and vapors, both pure and in mixture, are required. The application of thermodynamics to chemical reaction involves the use of free energies for the reactants and the products, for which heats of fusions, vaporization and formation as well as heat capacities are required.

A brief resume of the fundamentals and the properties of hydrocarbons required in applying thermodynamics will be made before discussing some of the applications in greater detail.

● **Fundamental concepts and equations.** The basis of all thermodynamic equations involved in hydrocarbon processing work are the 3 laws of thermodynamics, which are as follows:

First law. The first law is a statement of the conservation of energy, which includes the various types of energy; namely, potential energy, kinetic energy, and internal energy. Until relatively recent times the first two kinds of energy were all that was required in scientific work. Potential and kinetic energies form the basis for mechanics, their sum being known as mechanical energy. Internal energy is very important in the study of thermodynamics. The first law of thermodynamics states that heat and mechanical work are interchangeable. Conservation of energy is used in developing equations for the flow of fluids but is not sufficient in itself for the development of equations for phase equilibria, enthalpy, and entropy. For this the second law is required.

Second law. The first law relates the

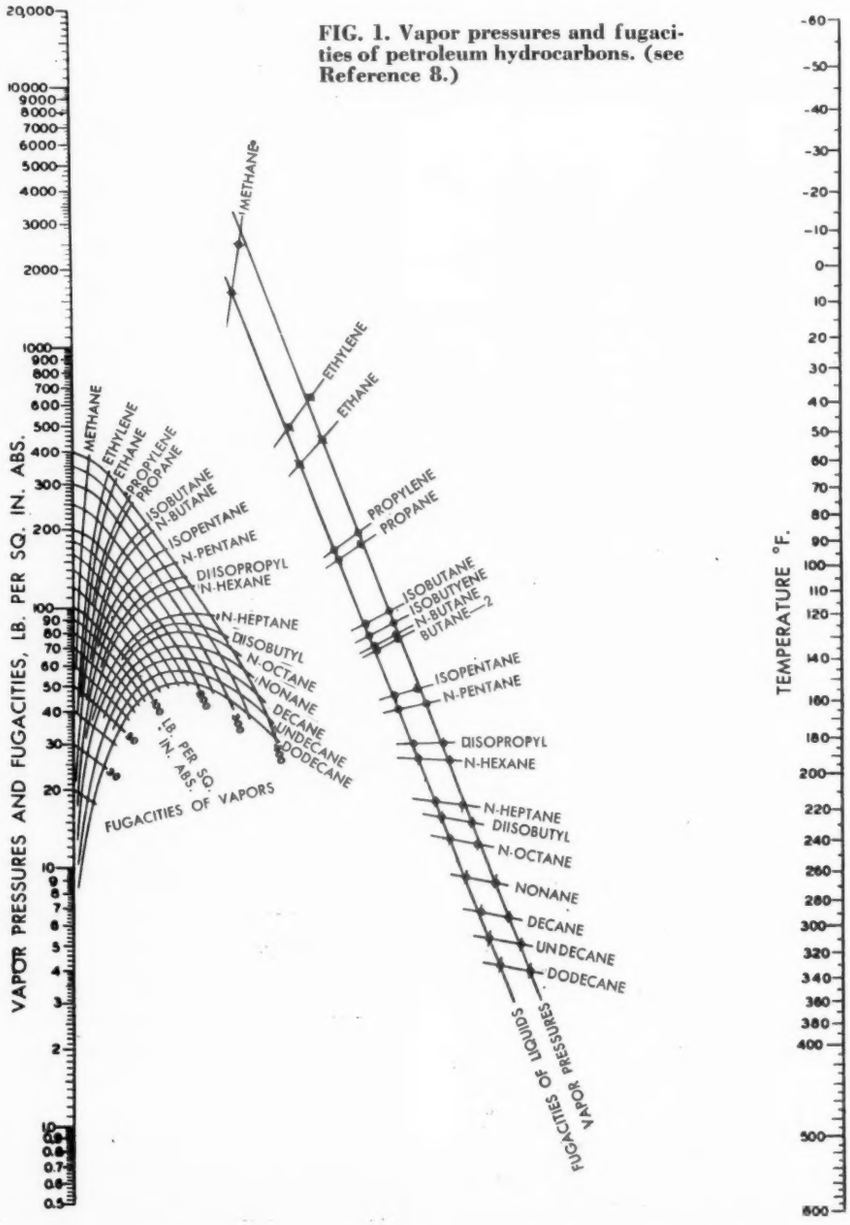


FIG. 1. Vapor pressures and fugacities of petroleum hydrocarbons. (see Reference 8.)

conversion of energy in one form to another but throws no light on the availability of energy. This is taken care of by the second law of thermodynamics through a property called "entropy." In simple language the second law states that heat alone will not, of its own accord, flow uphill and entropy is defined as an index of the unavailability or degradation of energy. Entropy *per se* is very seldom used in applying thermodynamics to hydrocarbons but it enters into the development of practically all the thermodynamic tools that are used so frequently. The first and second laws of thermodynamics, i.e. conservation and degradation of energy, together form the basis for most of the thermodynamics as applied to hydrocarbon processing.

Third law. The third law pertains to the absolute entropy of substances stating that the entropy of all crystalline substances is zero at absolute zero temperature. Absolute entropy is used in the computation of free energy for reactants and products.

The fundamental concepts of thermodynamics are summarized in Table 1, which is self-explanatory. Most of this discussion will be on application of thermodynamic equations and tools developed from the first and second laws.

The thermodynamic potentials used in applying these laws to hydrocarbon fluids are summarized in Table 2, which gives the definition and equations of these potentials. These equations, together with experimental data on the properties of hydrocarbons, are used in computing enthalpies, entropies, and fugacities for hydrocarbons and their mixtures. These computations may be made by means of generalized correlations of data using the generalized thermodynamic equations presented in Table 3. It will be noted that these equations are expressed in terms of α_R, the reduced volume residual. From the definition of the volume residual, i.e., difference between ideal gas law volume and actual volume, the equations shown in Table 3 follow from those given in Tables 1 and 2. A correlation of α_R as a function of T_R and P_R is required for the application of these equations.

● **Experimental data required.** The experimental data required in computing thermodynamic properties of hydrocarbons include:

(a) *Volumetric* data, i.e., pressure-volume-temperature measurements, including vapor pressures and critical data;

(b) *Calorimetric* data, i.e., specific heats, latent heats of fusion and vaporization, heats of combustion and formation;

(c) *Thermal coefficients*, i.e., Joule-Thomson coefficients and the isothermal effect of pressure on enthalpy; and

(d) *Phase equilibria* data, i.e., the amounts and composition of the equilibrium liquid and vapor at various temperatures and pressures.

Considerable work has been done on determining these experimental properties of hydrocarbons. Considerably more must be done to improve these thermodynamic methods, particularly for hydrocarbon mixtures. It is important to realize that an imaginative application of the methods of thermodynamics to experimental data can make a few data go much further. Thermodynamic methods are used to correlate the experimental data and extend their range as well as interpolate and check the data for accuracy by means of correlations.

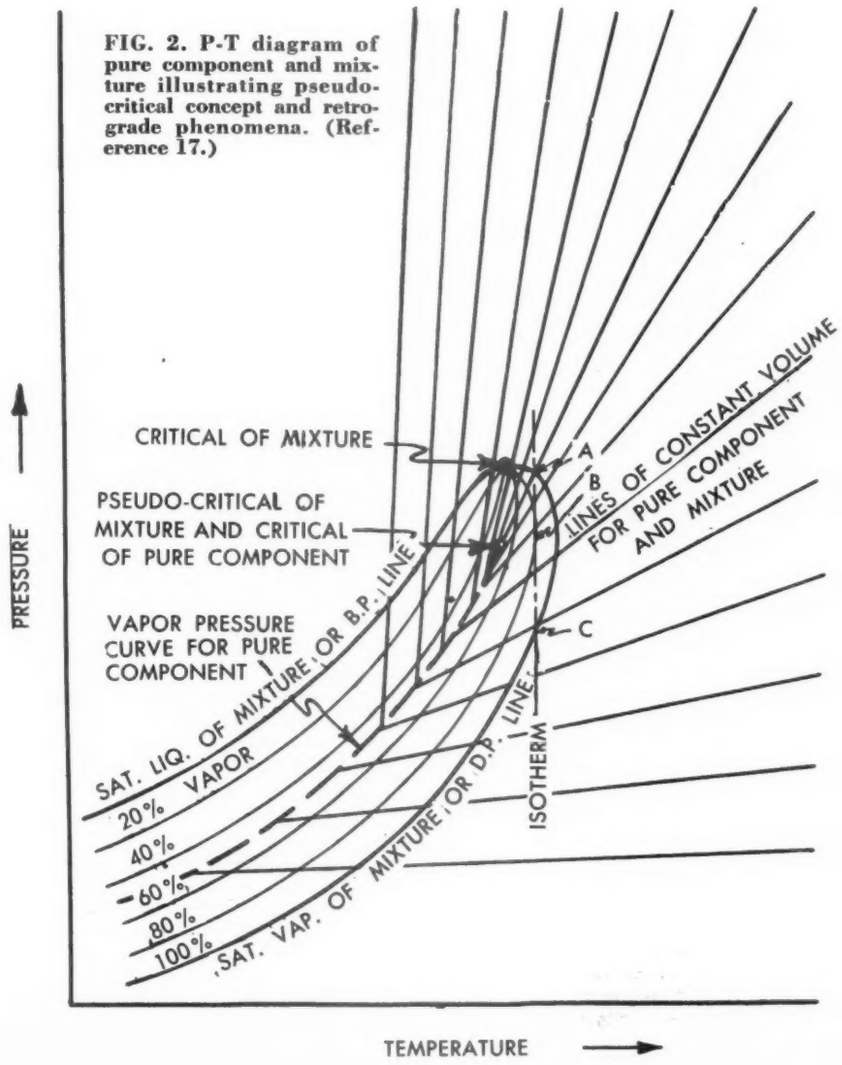
● **Vapor pressures and phase diagram.** Vapor pressure is a fundamental and useful property of single component hydrocarbon systems. Under some conditions vapor pressures of the components of a mixture may be used in computing phase equilibria. Even where fugacities are required for phase equilibria, vapor pressures are involved, as will be shown later.

The most widely accepted method of correlating vapor pressures is the Cox Chart, where the log of vapor pressure is plotted against the reciprocal of absolute temperature plus a constant. Hydrocarbon vapor pressures are straight lines on these scales. Fig. 1 is a vapor pressure nomograph, using the Cox scales, with fugacities shown for purpose of comparison. More will be said about fugacities later.

For a multi-component hydrocarbon mixture, the pressure vs. temperature plot consists of two rather than one line. See Fig. 2 for a comparison of the P-T plots for a single component and a mixture. The boiling point or saturated liquid and the dew point or saturated vapor lines join at the critical point, forming a phase border curve. The phase border curve shown in Fig. 2 for a hydrocarbon mixture is of interest in several respects. In addition to showing the per cent vapor lines, it shows the pseudo-critical concept and can be used to explain the phenomenon of retrograde condensation. These items will be discussed further.

When the lines of constant per cent vaporized, including the bubble and dew point lines, are plotted with the logarithm of the absolute pressure and the reciprocal of the absolute temperature as coordinates, the result is a phase diagram with straight lines of constant per cent vaporized that converge at a "focal point," when extrapolated as illustrated by the phase diagram for a naphtha-kerosine blend shown on Fig. 3. In addition to the focal point, the critical point is indicated. A point on the border curve, not indicated but of interest, is the "cricondentherm" or point of maximum

FIG. 2. P-T diagram of pure component and mixture illustrating pseudo-critical concept and retrograde phenomena. (Reference 17.)



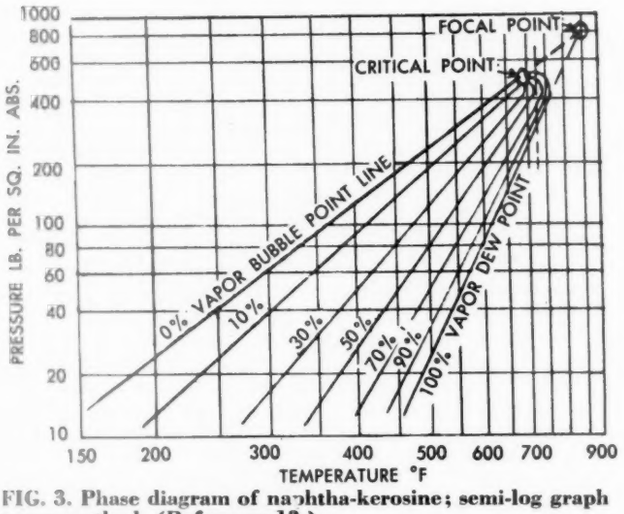


FIG. 3. Phase diagram of naphtha-kerosine; semi-log graph paper method. (Reference 13.)

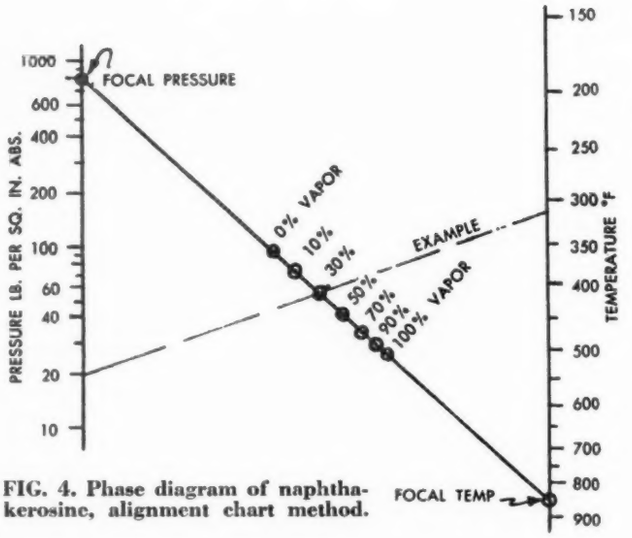


FIG. 4. Phase diagram of naphtha-kerosine, alignment chart method.

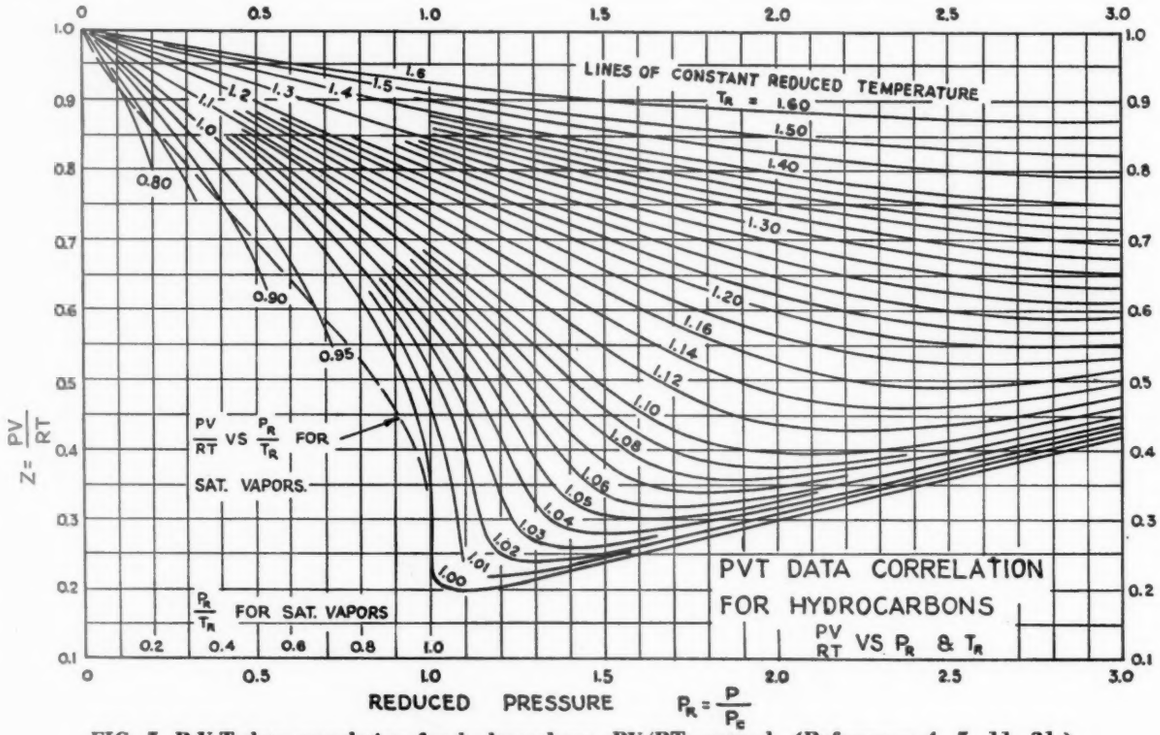


FIG. 5. P-V-T data correlation for hydrocarbons, PV/RT method. (References 4, 5, 11, 21.)

temperature. On the phase diagram shown in Fig. 3 the lines of constant per cent vaporized converge at the critical point. The phase diagram can also be plotted in nomographic form, using the logarithm of the pressure and the reciprocal of the absolute temperature as the scales. Such a phase diagram plot is shown in Fig. 4. Such a plot is possible because the constant quality lines are straight and all intersect at a common focal point in Fig. 3. The advantage of the alignment method is that several solutions may be plotted on the same plot. The disadvantage is that the critical point region is not easily shown, making it almost impossible to make retrograde estimations at the dome of the border curve. The phase diagram of hydrocarbon mixtures may be constructed by component phase equilibria calculations or by empirical correlations based on experimental data. In either of these methods the critical and the focal points are important. The focal point is a function of the critical point and the boiling range of the mixture.

● **Critical points and retrograde condensation.** For every fluid, whether pure or a mixture, there is a temperature and pressure where the liquid and vapor phases become continuously identical. This point, which is called the "critical point," is the highest point on the vapor pressure curve of a pure component. The critical point is on the top dome of the border curve of a mixture. Above this point it is impossible to have vapor and liquid in equilibrium. For a mixture, the critical point may be at or near the point of maximum temperature, the point of maximum pressure, or in between these points on the phase curves. The location of the critical point on the border curve of a mixture determines the type of retrograde phenomena occurring.

In the retrograde zone, which is the dome of the border curve between the critical and the cricondentherm points, it is possible to have partial condensation on isothermal expansion (or isobaric heating) and partial vaporization on isothermal compression (or isobaric cooling).

The word retrograde implies a reversal and it is used to differentiate between a simple change in quantity of a phase and one that reverses itself. Retrograde condensation or vaporization occurs when a phase appears, increases in quantity, reaches a maximum, and gradually decreases to complete disappearance during a process in which one independent variable relating to the system as a whole is continuously changed in

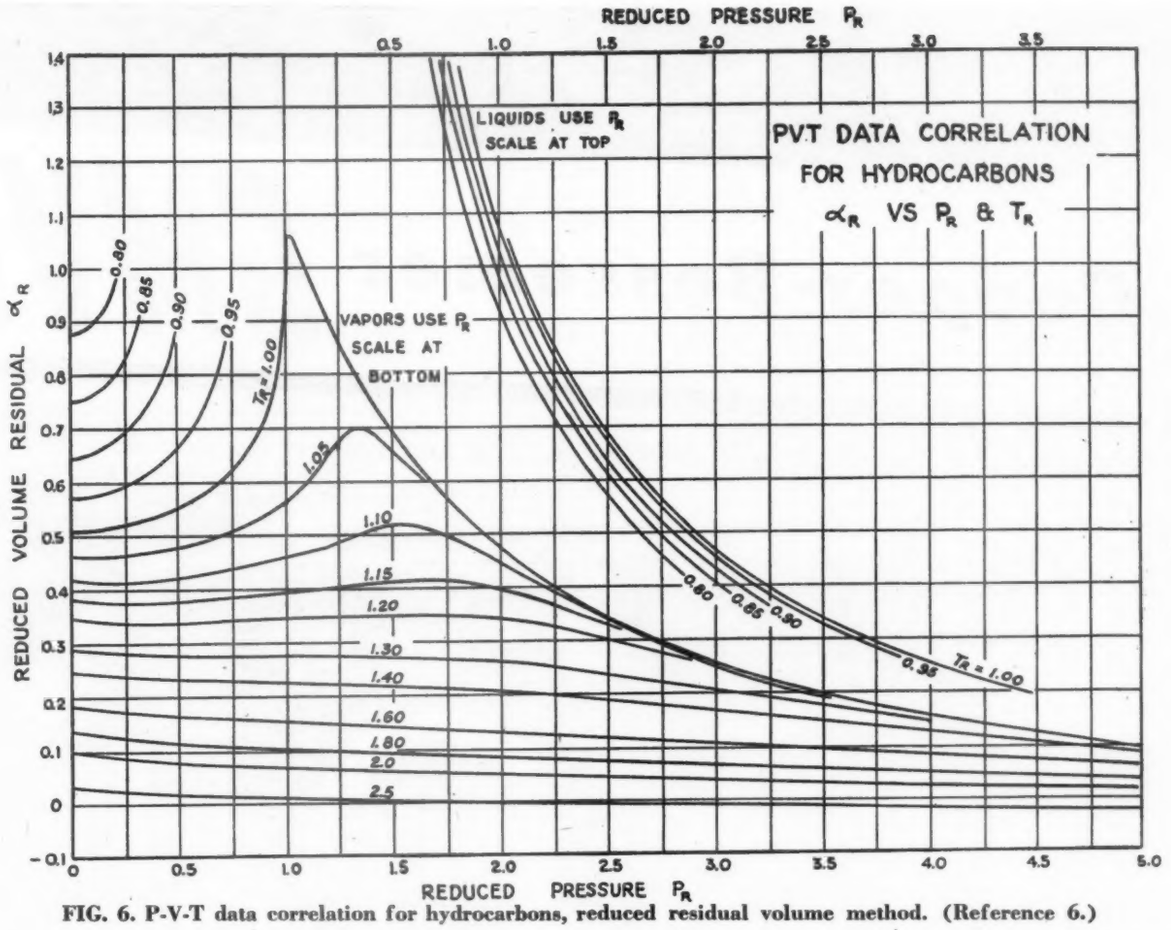


FIG. 6. P-V-T data correlation for hydrocarbons, reduced residual volume method. (Reference 6.)

value in the same direction, while other variables are held constant. Temperature and pressure are the variables most commonly associated with the phenomena, which is illustrated by the isotherm shown on Fig. 2. Had the critical point been nearer the cricondentherm point, isobaric retrograde condensation would occur. It is possible to have both isobaric and isothermal retgrograde condensation on the same mixture.

The critical point of a hydrocarbon mixture is a function of the composition, the critical temperature being a much simpler correlation than the critical pressure. Boiling range and "fill" have appreciable effects on the critical pressure. It is not an uncommon occurrence for the critical pressure of a mixture to be higher than the critical pressures of any of the components. This fact is important in phase equilibria calculations for high pressure operations.

Another important point in the phase diagram of a hydrocarbon mixture is the psuedo-critical point, which is used in correlating P-V-T data. For pure components the actual critical points are used in correlating the P-V-T data and computing the generalized properties. For multi-component hydrocarbon systems, the true critical point does not give satisfactory results, so a pseudo-critical point must be used instead. The pseudo-critical point is the critical point of an imaginary pure compound, whose isochors (lines of constant volume) coincide with the isochors of the mixture in question. This phenomena is illustrated by Fig. 2, where the isochors are shown crossing the border curve and joining the vapor pressure curve of the imaginary component.

The pseudo-critical point, which is a very powerful tool in applying thermodynamics to hydrocarbon mixtures, may be estimated as the sum of the products of the mol fractions and the true criticals for each component.

● **P-V-T correlations.** Pressure-volume-temperature behavior data are required for the vapor phase in applying thermodynamics to hydrocarbons. Correlations of such data are required in estimating vapor densities as well as the thermodynamic properties. Algebraic relations of P-V-T are known as equations of state, the simplest of which is the perfect gas law equation:

$$PV = RT$$

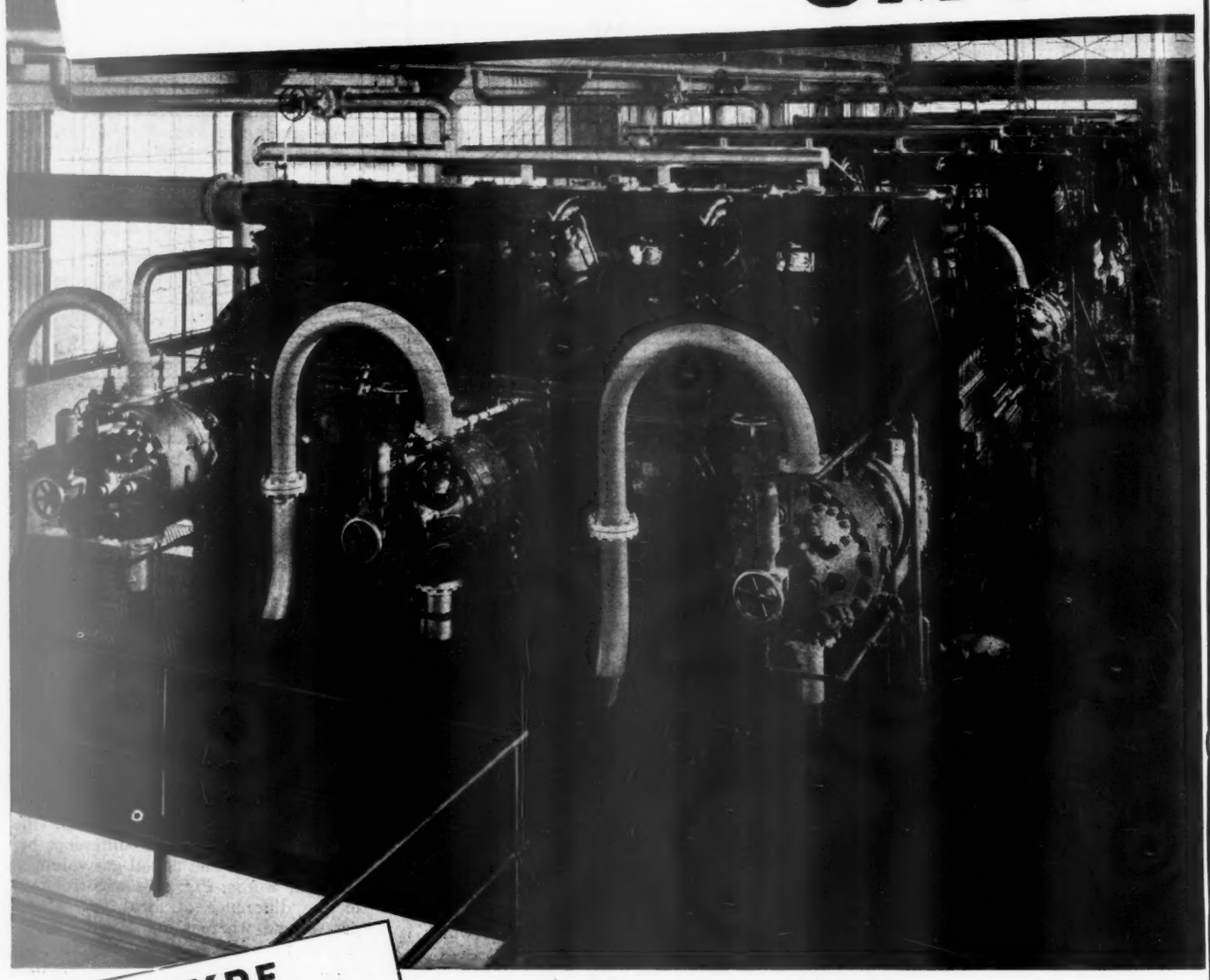
This simple equation can be applied to actual gases with sufficient accuracy for engineering purposes only at low pressures. There are several more accurate and complicated equations of state but the accepted practice in hydrocarbon calculations is to use a graphical P-V-T correlation. Two such correlations are presented as Figs. 5 and 6. In both of these correlations, deviations from the perfect gas law are plotted against reduced pressure and temperature, thus giving generalized P-V-T correlations and applying to all hydrocarbons.

The PV/RT plot given in Fig. 5 is accurate enough for computations of vapor densities for engineering calculations; however, this plot is not recommended for computing the derivatives of volume to be used in estimating thermodynamic properties of hydrocarbons. This is due to the fact that the data for all the hydrocarbons do not fall closely enough to the curves and also because the nature of the plot does not adapt it to accurate graphical differentiation. The correlation given in Fig. 6 is a plot of the reduced volume residual, which is the ratio of the volume residual to the critical volume residual, the volume residual being the difference between the ideal and actual gas volumes. In other words, Fig. 6 is a correlation of the difference of ideal and actual gas volume, whereas Fig. 5 is a correlation of the ratio of actual to ideal gas volume. In addition to using another correlating variable (critical volume residual), which makes for more accuracy, Fig. 6 is better adapted to graphical differentiation. Fig. 6 is recommended for such thermodynamic calculations, whereas Fig. 5 may be used in estimating vapor densities for engineering design purposes.

Both correlations may be applied to pure hydrocarbons and to mixtures, the latter being done by means of the pseudo-critical. Fig. 6 is the basis for the generalized thermodynamic correlations discussed later.

(The second installment will appear in an early issue.)

Cooper-Bessemer GMV's



Clean cut and neat as a pin describes this new Panhandle Eastern compressor station at Louisburg, Kansas. The five compact GMV's furnish a total of 5,000 compressor horsepower. In another building at this same location are nine Cooper-Bessemer Type 22 horizontals, some of which have now been in service for 16 years.

TYPE GMV ANGLE Compressors

New York Washington Bradford, Pa. Parkersburg, W. Va. San Francisco, Cal. Seattle, Wash.

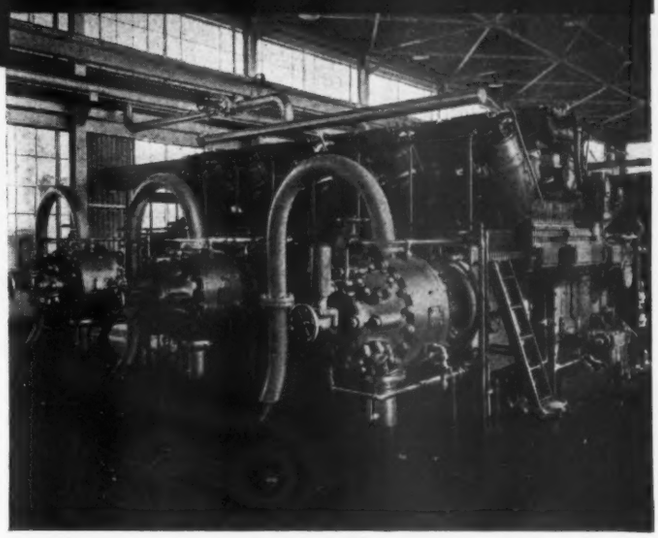
..on the PANHANDLE EASTERN line

. . . modern in every respect . . .
. . . in every respect reliable!

The first Cooper-Bessemer compressors built for the Panhandle Eastern pipeline were installed back in 1930 — big, rugged horizontals. As this great gas line grew, more Cooper-Bessemers were added . . . again and again. Today, the figure exceeds 90,000 hp — and with additional horsepower on order.

Through the years, Panhandle Eastern Pipe Line Company has recognized and evaluated the sound design, careful workmanship, and reliability that have always been No. 1 "musts" in Cooper-Bessemer production. That's why they reordered Cooper-Bessemers with each expansion.

The five compressors shown opposite are the first Type GMV's to be installed on the Panhandle Eastern line. Modern in every respect, these GMV angles are exceptionally compact, permitting important installation and housing economies. They have exclusive features and new design refinements that assure exceptional flexibility and long range efficiency. And, from base to water-cooled exhaust manifold, they have the engineered stamina and come-what-may reliability for which Cooper-Bessemer compressors of all types have long been noted. When you think of plans for the future, think of GMV.



Close-up view of one of the GMV compressors. Each unit is rated 1,000 hp, has 10 power cylinders, and in this case drives three compressor cylinders. The dependable, long-lived GMV, with its V-type, 2-cycle engine, is exceptionally compact, remarkably easy to maintain.

by **Cooper-Bessemer**

MOUNT VERNON, OHIO AND GROVE CITY, PENNA.

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SHRINK THREAD DRILL PIPE AND TOOL JOINTS

By **N. A. REBARICK*** and **C. SWARTSFAGER†**

AVAILABLE to the drilling industry today are several makes of "shrink" type tool joints for drill pipe. One make has a thread designed to eliminate last engaged thread failures and washouts through the threads.

EXCLUSIVE

An "acme" type of thread was selected to eliminate the notch effect at the bottom of the conventional "vee" type threads and give full, broad thread contact throughout the entire thread length. To prevent leakage and washout through threads a positive conical seal, on the small end of the joint ahead of the pipe threads, is made to precision measurement.

This joint design has practically eliminated tool joint last engaged thread failures, due to the broad flat crest and root engagement—both of which develop a very high resistance to torsion when shrunk together without lubricants.

*N. A. Rebarick is field engineer, Spang-Chalfant division of The National Supply Company, Tulsa, Oklahoma.

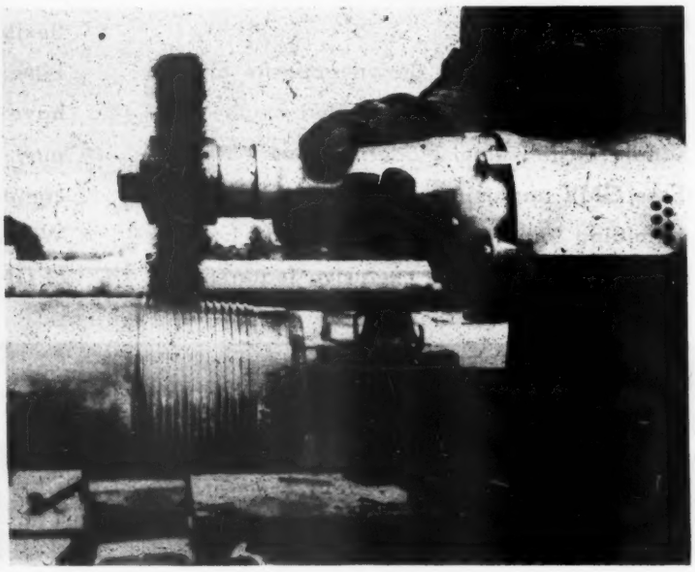
†C. Swartsfager is tool joint field engineer, The National Supply Company, Toledo, Ohio.

Left—The proper method of torch cutting worn or damaged shrink thread tool joints. A longitudinal cut is started from the tool joint taper thread end (box or pin) with the torch tip held approximately at 45-deg. angle, leaning toward the pipe, and cutting continued until the pipe end is observed inside the tool joint. At this point a slot is made for inserting a suitable wedge. The next operation is to flame-shave the metal off the tool joint, beginning at the opposite end and flowing the molten metal toward the wedge slot. Flame-shaving is continued in this manner until a channel 1 in. wide is made and within 1/16-in. or reasonably close, to the threads without damage to the threads or seal.

Right—A wedge is driven into the slot opening. Usually this wedging action ruptures the thin metal at the root of the channel, thus expanding the tool joint and releasing the shrink stresses. This permits the removal of the joint. To facilitate a more rapid rupture cold water is poured into the channel.

Using the wedge as a handle, proceed to remove joint in the usual manner.

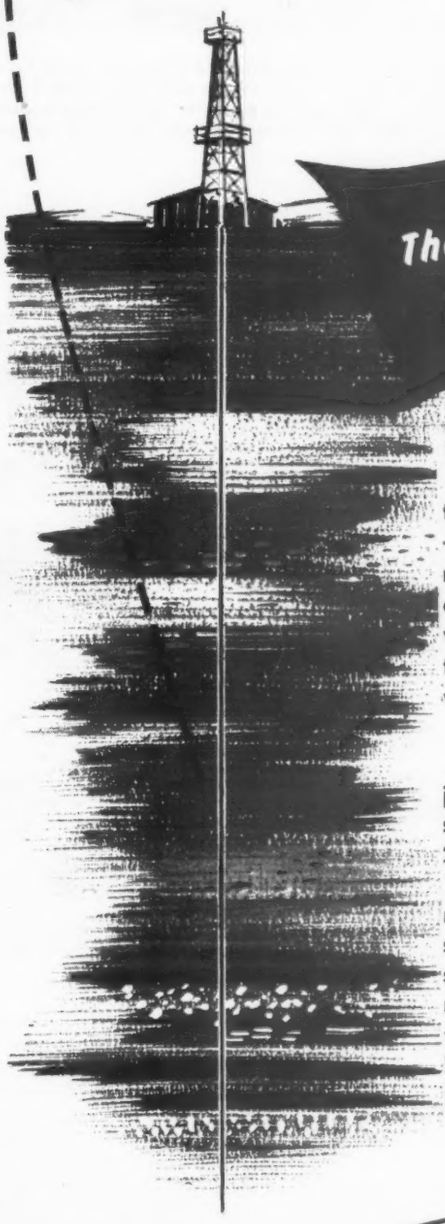
Threads and seal are thoroughly cleaned in preparation for application of new tool joint.



It's like having

FIVE EYES

that can see underground



The "SEALTITE"

SEES—AND TELLS—ALL THE FACTS
ALL THE WAY DOWN

THE Martin-Decker Sealtite Drilling Control Instrument "sees" *all* the facts about every foot you drill—and reports them accurately. This rugged sensitive instrument has not one—but *five*—control units in one compact steel box . . . a weight indicator with supersensitive vernier mechanism, mud pump gauge, torque gauge, tachometer, and a recorder that continuously and permanently charts *all* variations in weight on bit, mud pump pressure and drill pipe torque.

There is no job too large . . . no job too small . . . for the Sealtite. It has sufficient capacity to handle even 20,000 foot wells with ease—the big 16" dial face, illuminated for easy night reading, reads directly in thousands of pounds and points. And the special vernier gauge assures precise readings for lightweight operations where extreme accuracy is required. Because the fluid system is factory loaded and sealed, the Sealite is easily installed, easily moved from one location to another. Installation is fast and foolproof—only simple connections are necessary. When moving, diaphragm units remain connected to the instrument, eliminating adjusting and priming. There are no fluid leaks!

For complete, dependable drilling information . . . the *facts* that enable you to drill a better well in less time at less cost . . . rely on the Martin-Decker Sealtite—the master recording instrument that "sees" exactly what conditions are in your well.

HOME OF THE WEIGHT INDICATOR

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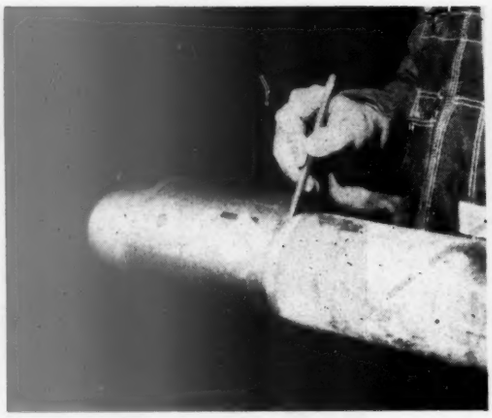
LONG BEACH, CALIFORNIA

SAN JOAQUIN VALLEY T. J. CULLEN, BAKERSFIELD, CALIFORNIA
MID-CONTINENT DISTRIBUTOR REED ROLLER BIT COMPANY, HOUSTON, TEXAS



Drill pipe and tool joint are correspondingly numbered and cold hand tight reference mark made on the pipe.

A general view of portable single joint heating furnace with tool joint being heated. This type of furnace can be heated with either natural or bottle gas. To attain a heat of 700°F. in the "shrink" area it requires an average heating time of 4 to 5 min. The top contains a sleeve that is removable to accommodate larger diameter joints.

After heating, tool joint is re-applied to the correspondingly numbered drill pipe end and screwed on by hand beyond the cold hand tight position to the predetermined hot mark.

The completed assembly is left to cool in the air before placing into drilling service.

Galling of pipe threads has been eliminated by hand power application in conjunction with the absolute gaging and uniform, predetermined make-up with the shrinking interferences.

A feature of this design is its simplicity. To be matched, one with the other, are two threads and two sealing surfaces.

The tops of the tool joint threads ride on the bottoms of the pipe threads but the reverse is not true. This further adds to the simplicity of design and to ease of gaging in manufacturing.

The pipe seal is cut on a radius, allowing it to "select" a seating position in the truly conical seal of the tool joint. Thus, a slight error in the taper of the tool joint seal has no effect on the desired contact between the two threads.

One of the most economical features of this design is the ability to remove joints worn beyond safe use and reapply to the same pipe threads new tool joints without the elaborate and heavy equipment of a machine shop. This can be done *at the rig* with just a small portable furnace and a few simple hand tools.

In conjunction with this equipment, it is necessary for the contractor to provide sufficient labor (usually a drilling crew) and a competent field welder. The removal and application of tool joints can be performed while the rig is in operation, or changing locations, or any other opportune time.

By following this procedure the contractor realizes a saving in shutdown time, trucking expense, and obtains a tool joint application typical to a mill applied joint, in the field, as recommended by the manufacturer.

Another advantage of this particular design of shrink connection is that good tool joints may easily be recovered from pipe that has failed, or become kinked beyond recovery. The burning out of a "Dutchman," however, is rather difficult to show photographically although the steps involved are fundamentally the same as burning off a tool joint.

Accompanying photographs are of actual operations in the field and the methods shown are recommended for efficient field applications.

★ ★ ★

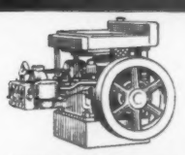
LUFKIN

PUMPING UNITS

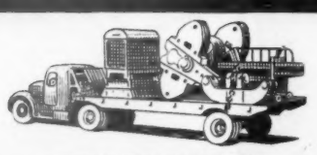
A TYPICAL LUFKIN INSTALLATION

Present day costs of operation and maintenance suggest the purchase of a Lufkin unit, an investment that will pay you dividends in economical trouble free service. Be safe . . . be sure . . . be satisfied . . . demand Lufkin.

LUFKIN PUMPING UNITS



LUFKIN-COOPER-BESSEMER ENGINES



LUFKIN OIL FIELD AND INDUSTRIAL TRUCK TRAILERS

INDUSTRIAL SPEED REDUCERS AND INCREASERS

DIVISION LUFKIN FOUNDRY & MACHINE COMPANY INDUSTRIAL, MILL AND AUTOMOTIVE SUPPLIES

LUFKIN FOUNDRY & MACHINE COMPANY LUFKIN TEXAS

MAKING RETIRED WIRE LINES DELIVER

By **HARRY ALLEN,** *Production Superintendent, Hogan Petroleum Company*

EXCLUSIVE

WE HAVE 10 wells on this property. They came in producing from 2500 bbl. to 8000 bbl. They were all rotary drilled and of course we have a great many old drilling lines around the property. In fact I haven't seen a *new* piece of wire rope for so long I wouldn't know how to handle it.

Fortunately most of our rope is of the preformed type. It is much easier to handle than non-preformed. There is no fraying at cut ends and we have never had a workman injured from handling the preformed, even after it was badly worn and had many broken surface wires.

On the property now we have several thousand feet of wire rope that we classify as "junk"—ropes that have served their initial use and in addition have seen service for many years around the property for almost every sort of job.

The "junk" tag, however, does not mean that the ropes do not have many safe jobs in them still.

When a rope is not in use we clean it, treat it with a dressing, and place in a waterproof building. Ropes so protected with a dressing and kept away from the weather will last almost the life time of the lease.

Particular care must be taken with the open ends on all non-preformed ropes. These must be seized or cut with a welding torch. If this precaution is not taken the end of the rope will fray and if it is moved around any or given rough handling, the loss from this strained fraying is very likely to run into 50 or 60 ft. of rope.

If the retired rope is to be used on a machine of any type where it works over sheaves or from a drum, the lubrication treatment must be sufficient to give the hemp core plenty of grease. A new rope is factory treated but old ropes, and especially ones that have been out in the weather and in a dry country, always need to be checked regarding the hemp center. This must be lubricated properly if the rope is to be used safely on a machine.

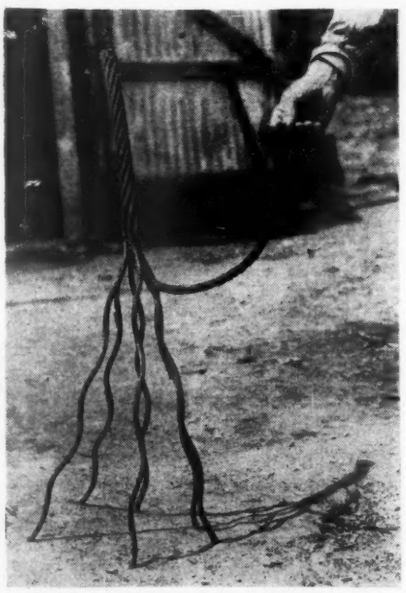
We have found that a bath lubrication is much better for getting grease into the hemp core. Bathing affords greater penetration. This is not always possible on location but it is desirable.

In placing fastenings on retired lines, particular care must be taken to see that the attachment is not placed on a section where there has been hard wear. It is a good policy to cut back at least 2 to 4 ft. before applying the fastening.

Although almost all the rope we now have on the location is of the preformed types, some is non-preformed. When workmen handle non-preformed rope that has been badly worn we insist that they wear leather gloves. This will prevent hand snags from the protruding broken wires. This precaution will go a great way in preventing minor injuries and cases of infection.

It has been our experience that there is a lot of life in most discarded lines. The war brought this forcefully to attention. I hope that operators, when steel is again available without restriction, will remember the lessons they have learned the last 4 years.

Rope care, frequent lubrications, and rope service all pay big dividends. The same care given new lines will pay even greater dividends. ★★★



Above—Harry Allen checks hemp core of used rope for lubrication needs. This section of preformed cable is used for training new workmen. *Left*—Allen, who has been in the oil industry since 1916, explains about placing fastenings on used wire cable. *Below*, he handles section of preformed wire rope. When handling non-preformed he always demands workmen wear leather gloves to avoid hand injuries, particularly if rope is badly worn.

SELECTION AND APPLICATION OF REFINERY INSTRUMENTS

By **ALFRED KRIEG***
Socony-Vacuum
Oil Company, Inc.

PART 3—LIQUID LEVEL

● **Preface.** Liquid level applications in the modern refinery are many and varied. By reducing storage capacity of vessels to a minimum and eliminating surge tanks in the modern process units, it becomes increasingly important to select and utilize the features incorporated in the variety of level controllers available today.

EXCLUSIVE

In continuous flow processes, it is of prime importance that the process be kept in balance. As the controller to regulate the liquid level must vary the rate of flow to or from the vessel, changes in these rates must be made in a manner to avoid any surges and sudden disturbances that will tend to upset the equilibrium of the entire process.

In considering level control problems, it should be realized that liquid level controllers are, in effect, ratio flow controllers, as they control the outflow proportional to, or equal to, the inflow over some period of time. This period may be in minutes or hours, and is the dominant factor in determining the proper type of control action to be applied.

The 3 methods most commonly used for liquid level control may be grouped:

(a) Constant level
(b) Averaging level
(c) Interface

● **Constant level.** In certain applications, the primary consideration is to maintain the level as constant as is possible, and the outflow may be varied at will to prevent the level from varying. For these cases, the time period referred to above must be relatively brief and the controllers must have a comparatively fast adjustment. When the level begins to vary from the desired point, the controller immediately changes the rate of outflow just enough to return the level to the desired control point, without setting up cycling by its own operation. This may be accomplished by the use of proportional control using a narrow throttling range.

On some installations, when fairly steady processing conditions exist, it may be desirous to hold both constant level and steady flow. A controller of the proportional reset type is recommended for this application. In other cases a more uniform outflow may be more important than a constant level. This is also accomplished by using the proportional reset control action adjusted for a wide throttling range.

● **Averaging level.** Frequently, the flow to a vessel will surge, due to causes that cannot be prevented or eliminated. When the flow from the vessel must be held very steady in the face of these surges and relatively large variations in the level are permissible, a controller with a suitable pneumatic control mechanism for averaging control action should be selected.

When the level varies due to a change in inflow, the averaging controller makes a much smaller and a much slower change in the rate of outflow, allowing the surge to be absorbed within the vessel, but constantly working to bring about the eventual return of the level to the normal point.

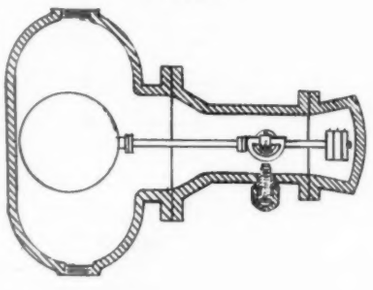
Alfred Krieg

Ultimately, of course, the quantity of outflow must be equal or proportional to the inflow, but this type of controller averages out the variations in the inflow over a long period of time. Surges in inflow are made to spend their force within the vessel so that the outflow varies only according to the average of the change in inflow. The averaging not only avoids creating surges itself, but also prevents surges in the uncontrolled flow from being pasesd on to the controlled flow.

The advantages of this averaging action are increased by the automatic reset of the controller. Reset is the function that continuously tends to restore the level to the set point, thus permitting the throttling range to be made wider and the control action slower than would be practicable in an instrument possessing throttling ability only.

For applications of this nature, the averaging reset type of controller is recommended. In effect, this control consists of an extremely wide and adjustable throttling range with automatic reset. This instrument is available with adjustable limiting stops that may be set for a predetermined high or low level, thereby providing a safety feature to eliminate the possibility of the vessel becoming flooded or completely empty.

FIG. 26



● **Interface control.** In certain processes, it is required that the interface of two liquids of different specific gravities be maintained very accurately. Also, the velocities of both heavy and light liquids must be held as constant as possible. Frequently, there is very little difference between the specific gravities of the 2 liquids and to measure this small force requires an instrument with high sensitivity and responsiveness. The absence of friction and lost motion are 2 requisites that must be considered when selecting an instrument for this application.

If proper care is not exercised, the tendency will be toward creating surges and difficulties will be experienced in handling demand changes.

For applications described above, one manufacturer has available a float type controller (see Fig. 26) with a knife-edge bearing supporting the float arm, suitably counterbalanced for the desired specific gravity. A pressure bearing with a small diameter shaft actuating the control mechanism is used in conjunction with the knife-edged support of the float arm.

Another method utilizes the float actuated torque tube principle (See Fig. 33). Due to the absence of packing glands in this displacement or buoyancy type instrument, this type is also reasonably friction free, thereby assuring increased sensitivity.

The instruments described above are available in the proportional, proportional reset, and averaging reset types of controller actions.

● **Level instruments.** Obviously, the many varieties of level instruments available are too numerous for discussion in this article; however, those in service at the Socony-Vacuum Paulsboro Refinery offer a representative cross-section of the types most commonly applied to refinery applications and will be discussed herewith.

The various types of liquid level measuring devices may be classified, generally, as follows:

1. Static pressure (Type A).
2. Float actuated (Type B).
3. Differential pressure (Type C).

*Alfred Krieg is supervisor of Instrument Department at Socony-Vacuum's Paulsboro, New Jersey, refinery.

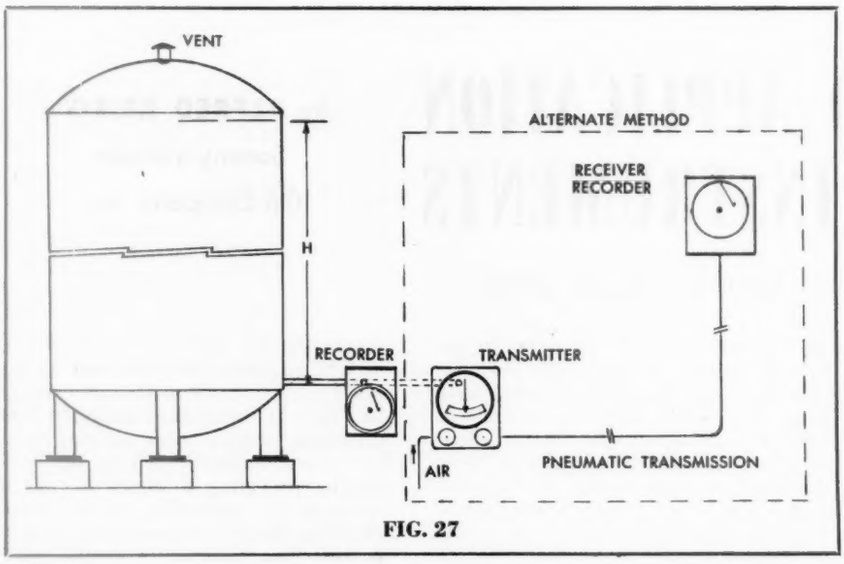


FIG. 27

● **Pressure gage system (Type A).** As the static pressure in an open vessel or tank varies directly with the head of liquid above it, the standard pressure gage or recorder represents a simple and inexpensive method for the measurement of liquid level. (See Fig. 27).

The range of the pressure gage obviously depends upon the maximum liquid height of the tank corrected for specific gravity. The chart or scale is calibrated in terms of linear feet and inches.

Using this method the instrument will read the actual level only when the instrument element elevation is the same as the bottom tap of the level.

When the instrument is situated at a point below the bottom tap, it becomes necessary to use a suppressed range to correct for the additional static head, if a zero reading at the instrument is to indicate or record a zero level in the vessel.

In order to overcome the suppressed range condition, or if it is desired to mount the recorder at a remote location, the pneumatic transmission type instrument may be installed. Similar applications of this method of transmission have been discussed in a previous article.

As volumetric measurement is nonlinear for spherical or horizontal cylindrical tanks, it can be used to measure level in feet and inches only. A suitable graph may then be plotted for volumetric content if desired.

● **Diaphragm box (Type A).** The diaphragm box type liquid level instrument for open vessels is designed upon the principle that the pressure at any point in an open tank or vessel is a measure of the height of liquid above that point. (See Fig. 28).

It consists essentially of a flanged metal box containing the molded rubber diaphragm, a conventional pressure indicator or recorder, and the small diameter connecting tubing. The air chamber is sealed from the liquid by the rubber diaphragm, a conventional pressure in- and contraction of air in the system without restraint.

The pressure caused by the column of liquid compresses the air system equivalent to the actual liquid head in the vessel. As the air-filled system eliminates elevation correction, the pressure indicator or recorder may be placed as much as 500 ft. away from the tank. The instrument must, however, be corrected for specific gravity of the liquid in which the diaphragm box is submerged.

This instrument may be used successfully in flowing or turbulent liquids or on corrosive or hot materials when properly sealed.

● **Air bubble or purge system (Type A).** The air bubble system for liquid level measurement in open vessels is designed for use on tanks or vessels open to the atmosphere or having very small pressures.

One of the methods employing this system, illustrated in Fig. 29, is to insert a tubular chamber or pipe full length or maximum level range into the tank in a vertical position, allowing a space at the bottom for sediment.

The recorder is the conventional pressure recorder, calibrated for a feet and inches chart. It may be installed a considerable distance away with piping or tubing run between it and the top of the immersed pipe or chamber. At some point near the tank, an air line with a pressure regulator and a gage is connected into the recorder piping. In operation the air bubbles out at the lower end of the pipe and prevents the liquid from rising. This also increases the air pressure in the piping and an increase of liquid level causes the instrument to record it in feet and inches.

This type system is especially adaptable when measuring the level of corrosive liquids or those containing suspended solids. It has a further advantage in using air or gas as a purging medium, i.e., the possibility of locating the pressure gage or recorder at levels other than the minimum liquid level.

● **Ball float (Type B).** One of the more flexible and simpler instruments for level measurement makes use of an air pilot actuated by a cam attached to the float operated shaft (See Fig. 30).

FIG. 28

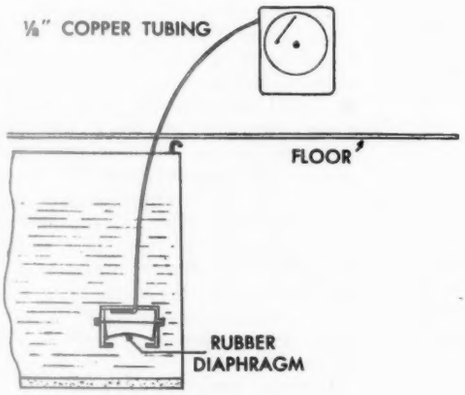
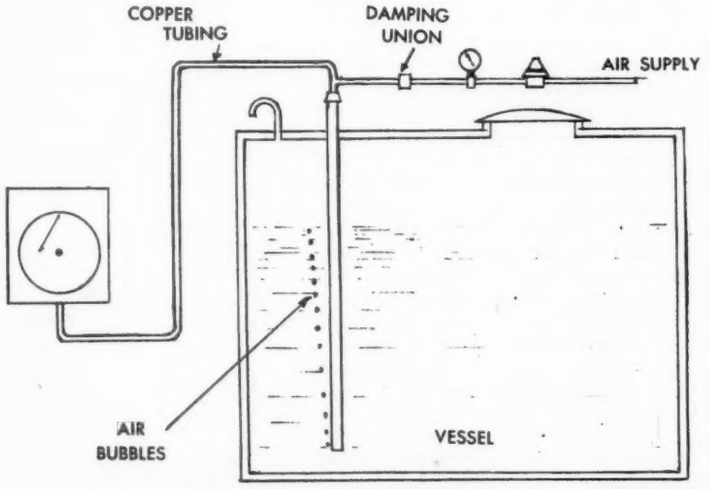


FIG. 29



SYMBOL FOR TOUGHNESS

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The symbol for toughness in Deepwell Pumps is "Moloy"—developed, named, and processed by Pacific. "Moloy" didn't just happen—like other outstanding contributions in the field of industrial science, "Moloy"—an alloy unbelievably resistant to sand, high pressure, abrasion, corrosion, and temperature—is the result of intensive metallurgical research, combined with the sure knowledge resulting from years of actual field experience. Liners of Pacific "Moloy" are honed to a high mirror finish, and are held to the closest tolerances. That is why Pacific Deep Well Pumps give long, trouble-free service. And remember, only from Pacific can you reap the positive benefits assured by "Moloy" liners. *Be Specific—Buy Pacific.*

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33-P

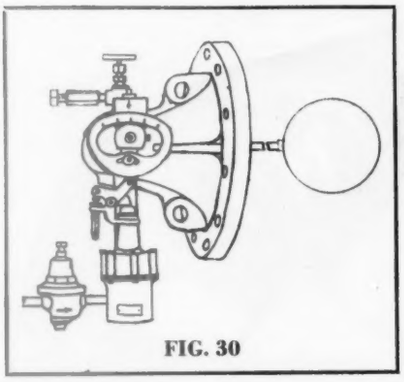


FIG. 30

Several models are available in the cage and flange types. The flanged model is designed for direct insertion of the float into the vessel.

The actuating cam is directly attached to the float shaft, eliminating linkages, levers, etc., and through a ball bearing roller operates the pilot. The cam is adjustable to a certain increment of float travel to produce a definite predetermined flow as required to maintain the desired level condition. Any point in the level range from maximum float travel with fine graduated throttling action to a short travel with fast action is adjusted for at the cam.

The balanced compound pilot is positive and simple, yet a very small movement of the float will vary the pressure to the control valve. The pilot will operate with air, gas, or water pressure from 15 to 125 lb. per sq. in. gage.

There are probably more level controllers of this type in refinery use than any other type, for they cover a wide scope of general applications on fractionating towers, side stream strippers, reboilers, accumulators, etc.

When controlling the level of tar and other highly viscous products a definite advantage is obtained in employing the use of the internal type ball float. As the float is situated inside the vessel, it permits control of the product at the higher vessel temperature, thereby reducing viscosity and eliminating sluggishness. Wider rangeability is also possible by lengthening the float rod.

● **Flexible shaft (Type B).** The packless flexible shaft type level indicator or controller, shown in Fig. 31, operates on the principle of force due to buoyancy rather than a float riding on a changing level. Sensitivity is such that a buoyancy change of less than 6 oz. will result in an air change of 2 to 15 lb. per sq. in. gage, resulting in full travel of a diaphragm control valve.

Float motion is transmitted through the walls of the pressure vessel by means of a flattened flexible member similar to a Bourdon tube. This packless flexible shaft eliminates all linkage, internal bearings, and packing glands.

This instrument is of the fixed throttling type and on standard applications permits the use of a small 3½-in. diam. ball float and a short float arm. Due to the inherent sensitivity of this controller, overall dimensions are small. It may be mounted on a flange and installed directly into the vessel, and is also supplied as a float chamber assembly.

It may be used for open or closed vessel service and is available for high temperatures and pressures, and for smooth throttling level and interface control on immiscible liquids having a specific gravity difference as small as 0.050. They are also applicable for use on reboilers for continuous condensate draining service, which results in improved temperature control as compared to the intermittent condensate trap.

● **Tubular float—null balance (Type B).** In the application of the null balance principle (see Fig. 32) to the indication and control of liquid level, a packless flexible disk that supports the horizontal balance arm is used to seal off the process liquids. A change in liquid level on the tubular float, which extends the full length of the tank, is balanced pneumatically on the opposite end to transmit an air pressure proportional to the change in level. With this construction the entire weight is supported by the friction-free flexible disk. Thrust pivots are provided in event the system operates under pressure. These meters are normally calibrated in inches or feet of level, which necessitates a correction for the change in density due to temperature variations of the liquid. The temperature correction, however, is unnecessary if the receiving meter is calibrated in units of weight, for this system balances the buoyant forces. The system remains mechanically in the same position at any point on the scale so that linear characteristics are inherent.

The elimination of the conventional packing gland is an advantage particularly when measuring acid levels and other corrosive liquids. This method is employed for measuring levels in spheroids at the Paulsboro refinery with float lengths of 28 ft.

As an air pressure change proportional to the change in level takes place, it is only necessary to tie in a conventional recorder controller of the proper range in order to utilize this instrument for level control applications.

● **Buoyancy or displacement (Type B).** The displacement type level indicator or controller embodies a float as a primary element, its length determining the range of the instrument.

Weighted to submerge in the heaviest liquid it will encounter, the float is either suspended in the vessel itself (see Fig. 33) or in a chamber outside the vessel, as is illustrated in Fig. 34. In this case the liquid enters the chamber through the 2-in. equalizer connection. With or without a chamber, the float hangs freely from a bracket attached to the outer end of the float arm. Two shoulders on the float arm limit the upward and downward movement. Bracket design also provides a stop to prevent excessive upward movement of the float. The other end of the float arm is attached to a torque tube. The torque tube screws rigidly into the body of the instrument, providing a leakless connection for frictionless mechanical transmission of float movement to the mechanism of the indicating or controlling instrument.

One manufacturer uses a torsion spring also attached to the float arm and adjusted so that the combination of torque tube and torsion spring just sup-

FIG. 31

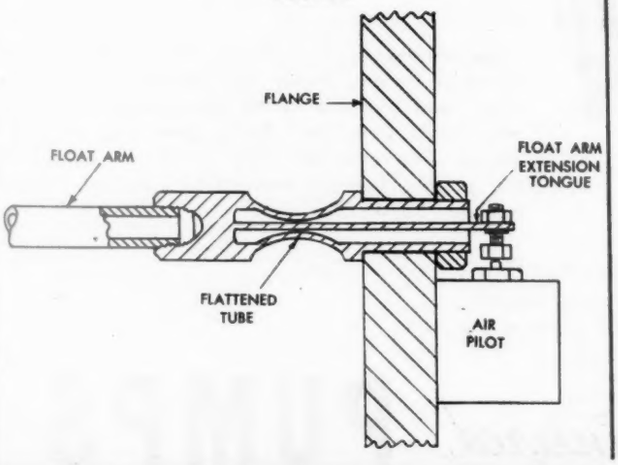
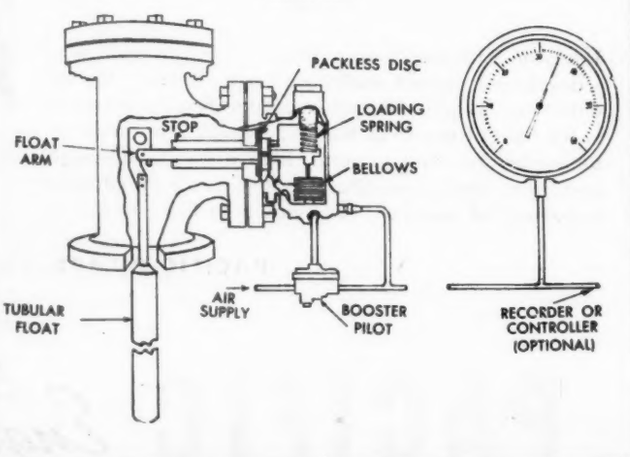


FIG. 32

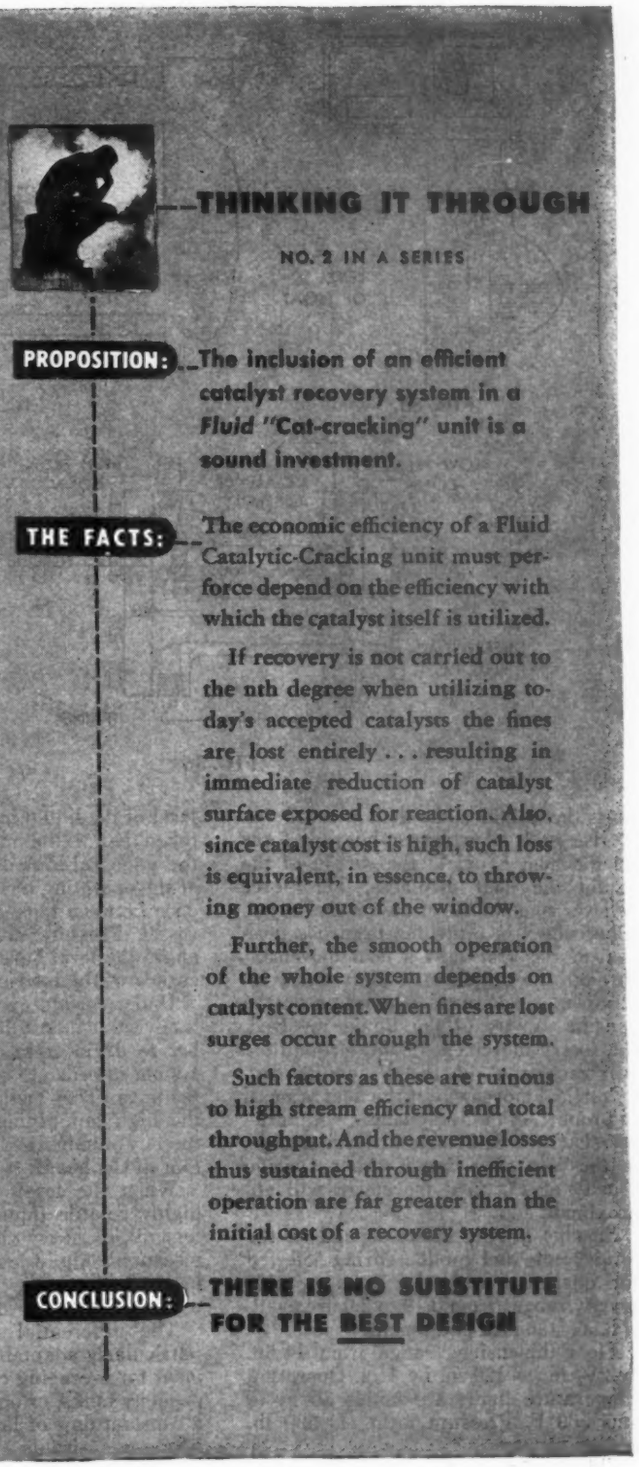


measured. Instead, careful consideration highlights again the fact that every individual refiner requires an individual solution to his problem.

However, for quick evaluation, probably the best surface yardstick of earning power rests in the flexibility of a *Fluid* unit . . . its ability to "follow the market" in product distribution and charge. Kellogg engineers design this flexibility into *Fluid* units in many ways. The effect that such design can have on overall operating results is readily apparent when you consider the possible variation in just four of the elements of design:

1. The ability of *Fluid* units to obtain optimum cracking on a wide range of charge stocks from reduced crude to light gas oil, which is an inherent advantage of the *Fluid* principle itself.
2. The possibility of varying the catalyst bed level in the reactor and changing the catalyst-oil ratio at will for optimum product distribution.
3. The necessity of maintaining catalyst selectivity at optimum value with controlled particle size—and with minimum replacement—for economical and efficient operation.
4. The selection of proper balance between external and internal thermal facilities for optimum flexibility and economy.

Here then is the crux of the economic feasibility of the small *Fluid* unit. *Ultimate earning power*—the true measure of value in any refining operation—*depends on designing into the unit the necessary engineering features to meet a specific competitive situation that exists now* . . . and to provide an inherent flexibility that will extend this competitive advantage into the foreseeable future. In other words—"There is no substitute for the best design."


THINKING IT THROUGH
NO. 2 IN A SERIES
PROPOSITION:
The inclusion of an efficient catalyst recovery system in a *Fluid* "Cat-cracking" unit is a sound investment.
THE FACTS:
The economic efficiency of a Fluid Catalytic-Cracking unit must perforce depend on the efficiency with which the catalyst itself is utilized.
If recovery is not carried out to the nth degree when utilizing today's accepted catalysts the fines are lost entirely . . . resulting in immediate reduction of catalyst surface exposed for reaction. Also, since catalyst cost is high, such loss is equivalent, in essence, to throwing money out of the window.
Further, the smooth operation of the whole system depends on catalyst content. When fines are lost surges occur through the system.
Such factors as these are ruinous to high stream efficiency and total throughput. And the revenue losses thus sustained through inefficient operation are far greater than the initial cost of a recovery system.
CONCLUSION:
THERE IS NO SUBSTITUTE FOR THE BEST DESIGN

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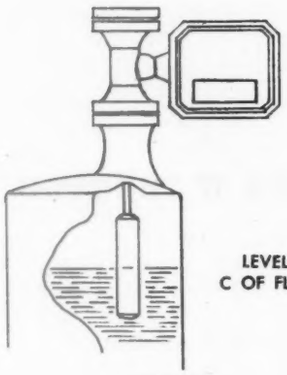

FIG. 33

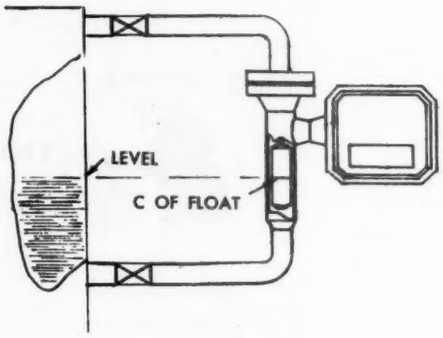

FIG. 34

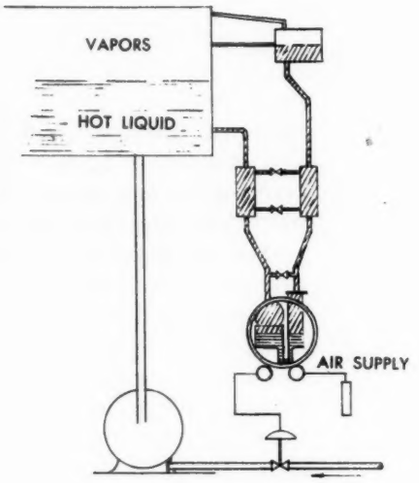

FIG. 35

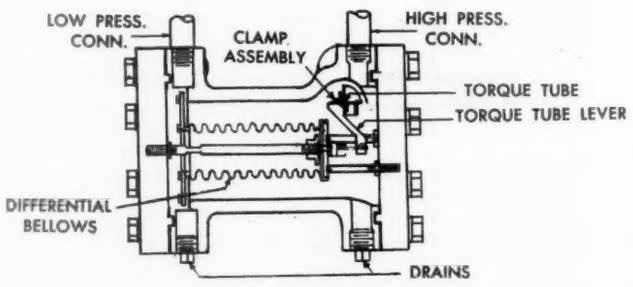

FIG. 36

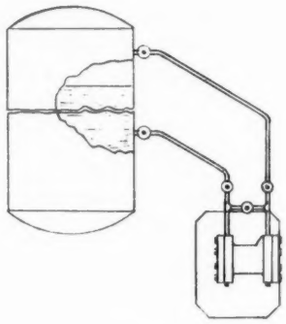

FIG. 37

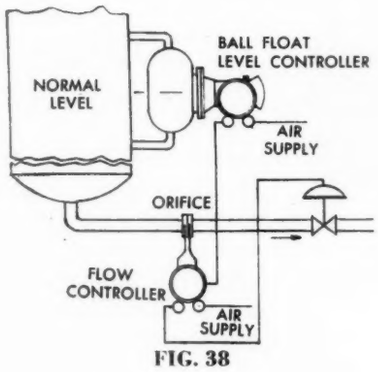

FIG. 38

ports the weight of the float at zero level. A rise in level exerts a buoyant force on the float equal to the weight of the liquid the float displaces. This force relieves some of the stress on the torque tube, which in returning toward a position of rest transmits a float movement through the torque tube shaft to the instrument mechanism. Depending on the specific gravity of the liquid involved, the rotary movement of the torque tube will vary from 4.6 to 8.6 angular deg.

Vertical movement of the float is small in proportion to level changes within the vessel. For a full range of level change, in the case of a liquid with a specific gravity of 1.0, float movement will approximate 1 in.

Specific gravity limits depend on the torque tube and torsion spring selected for operation with the float. Specific gravity ranges from 0.19 to 2.0 are available as standard equipment.

Float dimensions range from 14 in. by 2½ in. to 120 in. by 1 in. Operating temperature limits are minus 30°F. to plus 500°F. Pressure rating is 600 lb. per sq. in. gage.

This instrument is suitable for many applications on open or closed vessels and may be used for smooth throttling control, averaging level control, and interface and gravity control.

● **Differential (Type C).** The differential type liquid level gage is the conventional float type instrument similar to that which has been successfully used for flow measurement. It operates on the mercury U-tube principle and is available in various ranges of water differential. (See Fig. 35).

Installed on liquid level, the gage measures the difference in pressure between a tap taken above the maximum level of the liquid in the vessel and a tap taken below the minimum level. With the gage calibrated for specific gravity at the operating temperature, this difference between taps gives the level in the vessel. Pressure changes in the vessel above the level have no effect on the accuracy of the instrument.

Under certain operating conditions, it is advisable to install a condensate chamber to drain from a high point in the system in order to obtain accurate level readings. This method insures keeping the high tap piping filled with liquid, thereby eliminating error due to variation of the head.

When the level of corrosive liquid, highly volatile liquid, tar, sulphur-content oil, or heavy viscous fluid is being measured, liquid seal chambers should be used to prevent such liquid from entering the mercury chambers.

The differential type instrument is particularly adaptable to level measurement for averaging control on surge and capacity tanks, or on applications where a constant flow of liquid from the vessel is more desirable than the control of liquid level within definite small limits.

For local mounting, the mechanical type of differential instrument is most generally used. For remote installations, however, they are obtainable with either electrical or pneumatic transmission.

As this instrument is so similar in design to the conventional differential flow meter, it may be used for level or flow measurement.

● **Aneroid differential (Type C).** The aneroid manometer or assembly (Fig. 36) is particularly adaptable to liquid level applications because of its exceptional range and its ease of calibration to obtain unusual range intervals.

The balancing agent in this instrument is a torque tube actuated by a strong yet sensitive metal bellows. The torque tube is also the means of connection between the bellows assembly and the instrument mechanism. The body or housing of the torque tube screws into the manometer body and supports the torque tube, coupling assembly, and the free end of the bellows. No bearings or springs are involved and friction and lost motion are held to a minimum. This type of manometer is one of the few in which mercury is not required to actuate the mechanism.

Fig. 37 illustrates an application in which the tank or vessel has been tapped at points above and below the levels between which measurement is to be made. The lower opening connects to the low

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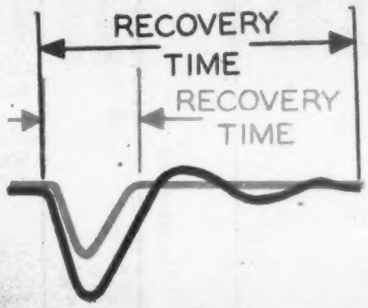
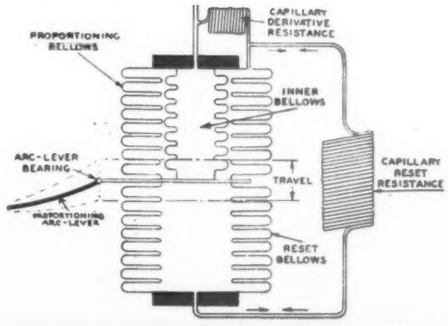
In one industrial process after another, the HYPER-RESET function of Foxboro's Stabilog Control is applying the same sort of INSTINCTIVE BALANCE for smoother, more efficient operation. Instead of merely responding to the amount of process upset, HYPER-RESET also senses the rate of disturbance . . . and adds an extra corrective action simultaneously. This combination of two corrective actions . . . one measured to the amount of upset and the other to the rate . . . means recovery from a disturbance in as little as one fourth the usual time. It also means the degree of upset is kept to a minimum.



Here's the difference HYPER-RESET makes. The longer, more involved curve shows recovery time in a typical process before the development of HYPER-RESET. The shorter, simpler curve shows how rapidly and smoothly the HYPER-RESET function stabilizes the same process. Usual recover time is cut by as much as 75%.

Today, when profit margins are narrowing rather than widening, you need the competitive advantages of Foxboro Stabilog Control with HYPER-RESET. **The Foxboro Company, 130 Neponset Avenue, Foxboro, Mass., U. S. A.** Also Montreal, Canada. Branches in principal cities.



How HYPER-RESET Stabilizes *Faster*

HYPER-RESET employs an automatic reset system similar to that of a standard Stabilog Controller. Supplementing this are selective air-capacity tanks and the special capillary resistance shown in the diagram at left. This derivative resistance is so arranged as to produce a definite pressure drop for any given rate of pen deviation. In turn, this pressure difference produces an augmented valve position which exceeds, at any time, that which would result from proportioning-plus-reset action only. Thus, HYPER-RESET provides extra corrective action — *instantly* — at a rate precisely measured for the process requirement.

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pressure side of the manometer and the upper tap to the high pressure. A constant head will exist on the high pressure side, its value depending on the inter-tap distance regardless of level variations within the vessel. When liquid level is opposite the upper connection, pressures on both sides of the manometer are the same, resulting in zero differential. As the level drops toward the lower tap, differential pressure increases toward a maximum. Regardless of the head, differential pressure will vary as liquid changes occur, causing the manometer bellows either to expand or contract.

The aneroid manometer is adapted for a particular liquid level application by the selection of a torque tube with a range sufficient to include the constant head and the variation of head on the vessel side. The instrument can be calibrated for intermediate ranges and adjusted to read zero when vessel level is either opposite the upper or lower manometer taps, or above and below a specified datum line.

When measuring or controlling the level of light hydrocarbons, it is possible that moisture may condense in the differential lead lines to the manometer. This will cause inaccurate readings. The absence of mercury in this manometer permits easy removal of the condensate by blowing down both the meter leads and the meter body as required.

This instrument is available for controlling in the proportional, proportional reset, and averaging reset bands and due to its wide range is most desirable for averaging control.

● **Dual level control.** Under certain operating conditions, the pressure drop across a control valve changes because of surges in the process. This may be attributed to a variation in steam supply to a pump, or to some other cause.

Obviously, no level controller can be expected to handle such conditions alone because it would be upset by changes in flow through the valve that were not caused by the operation of the controller. Where these conditions exist, the two-controller method is used. (Fig. 38.)

A flow controller regulates flow at the valve, whereas the liquid level controller holds the level within the desired limits by shifting the set point of the flow controller. The flow controller can be very fast acting to correct for the quick changes in pressure drop and the liquid level controller can retain its necessary slow action. In this way the flow controller maintains the flow set by the liquid level controller irrespective of changes in upstream or downstream pressure at the valve.

(Part 4 of Mr. Krieg's article will be published in an early issue.)

P 094.6

HANDY BELT TRANSMISSION CHART

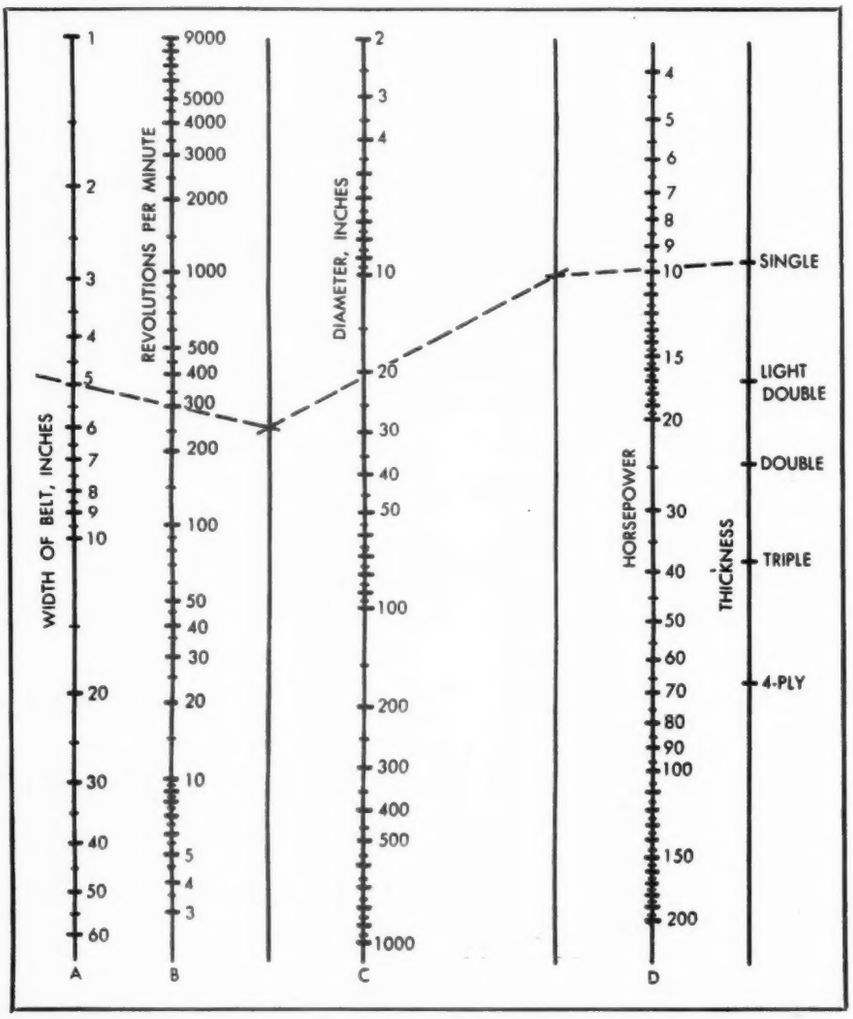
W. F. SCHAPHORST

THIS chart quickly tells nearly everything one might want to know about a flat leather belt drive. Simply zigzag across the chart as indicated by the dotted lines and you can get whatever estimate is required. The chart includes all widths of belts varying from 1 to 60 in., all revolutions per minute varying from 3 to 9000; and all pulley diameters from 2 to 1000 in. It also gives the horsepower from single ply, light-double, double, triple, and four-ply belts.

To use the chart, find the width of belt in inches in column A and then run a straight line through that width and the pulley revolutions per minute in column B and locate the intersection in column C. Then from that point of intersection run through the diameter of the pulley in inches in column D and locate the intersection in column E. Then finally, from that point of intersection run over to the thickness of the belt in column G, and the intersection with column F gives the horsepower. If, after reaching column E, the horsepower is known and it is not certain whether the belt should be a single, light-double, double, triple, or four-ply, run a straight line through the intersection in column E and the horsepower in column F and the intersection with column G will give the number of plies or thickness of the belt.

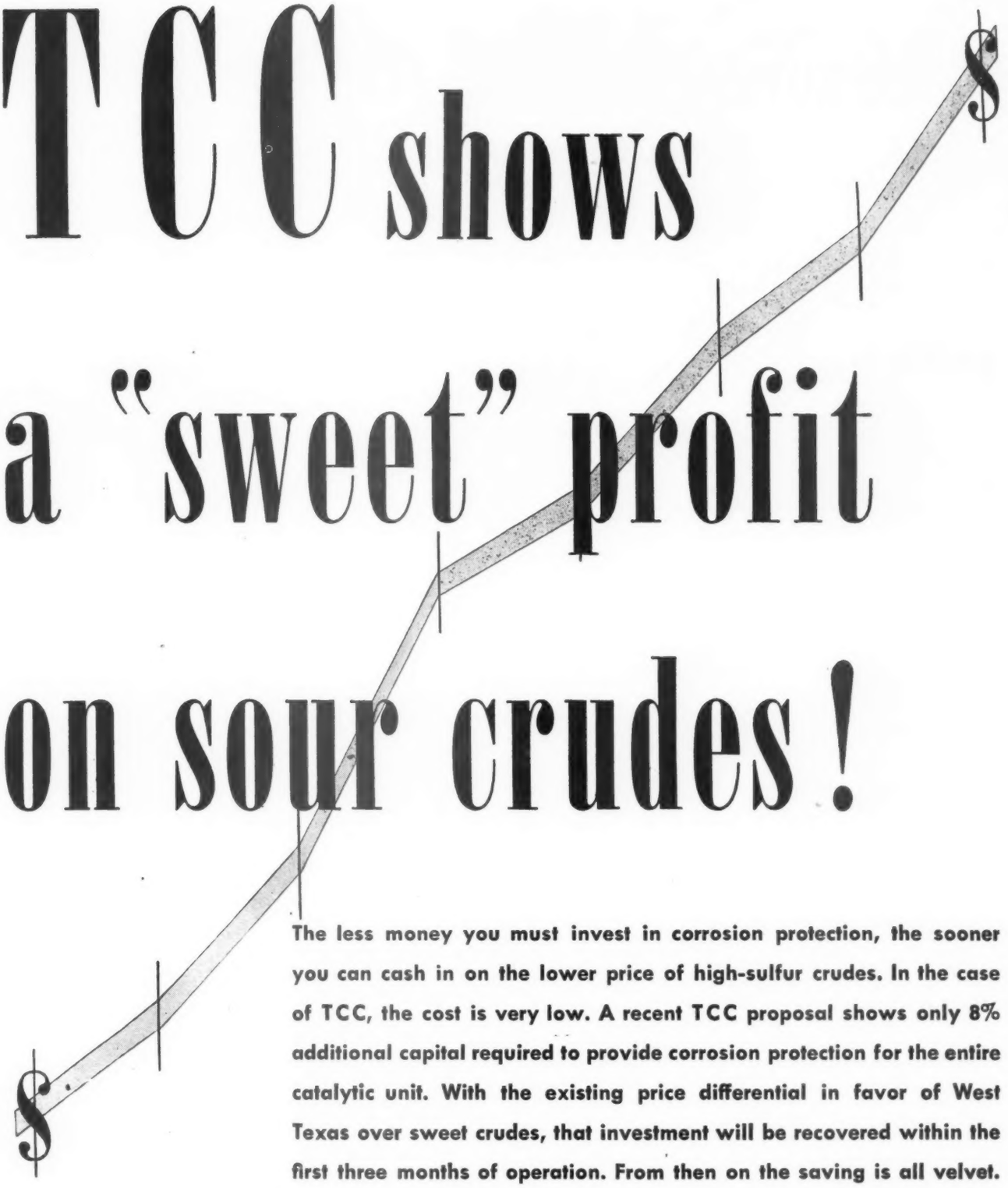
Regarding column G, these spaces are based on figures that were determined by the late celebrated Frederick W. Taylor who originated efficiency engineering. Thus, a light-double belt will transmit about 33 1/3 per cent more power than a single belt. A double belt will transmit about 50 per cent more than a single belt, a triple belt will transmit about twice as much, etc.

If the thickness of the belt, horsepower, diameter of pulley, and revolutions are known, and it is desired to determine the width of the belt, begin at the right of the chart and zigzag over toward the left, and the width is found in column A. Thus, if four of the factors are known, the fifth is easily determined by simply running straight lines across the chart as has already been explained.



For example, the dotted zigzag lines across this chart show that if the width of the belt is 5 inches; the pulley makes 300 r.p.m., and is 20 inches in diameter, and the belt is a single-ply belt, it will transmit 9.8 hp. ★ ★ ★

TCC shows a "sweet" profit on sour crudes!



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HOUDRY CATALYTIC PROCESSES

AN IMPROVED LAYOUT FOR STEAM DRILLING RIG

By **WILLIAM J. DAVIS,** *Associate Field Editor*

THE heavy equipment required by present day drilling practices has thrown drilling superintendents more and more upon their own resources for methods of moving the unwieldy and bulky machinery as well as the auxiliary equipment that is needed to keep a power or steam rig operating.

EXCLUSIVE

Through the war years tool pushers and superintendents used their wits as never before to make their equipment last and used it to the best advantage in the constant search for new sources of petroleum. The problem of transporting the bulky equipment while tires and gasoline were on the rationed list brought out many ideas of how machinery could be combined into more suitable truck and trailer loads, how rigging-up and tearing-down time could be held to a minimum, and what could be done to keep actual drilling time at a maximum and down-time at a minimum.

The tendency has been to concentrate related equipment into unit loads and to simplify piping arrangements, yet keep the rig flexible.

One example of the many to be found in the field today is the steam rig of Earl Callaway Drilling Company operated in the Falfurrias, Texas, area by E. E. Mosher, tool pusher, who has combined many old practices and new ideas in getting his rig in the best possible shape for efficient moving and operating over a long period of time.

Mosher's principal thought and aim was to speed up handling and moving equipment from location to location and to get as many actual drilling hours out of each tour as possible. The main test for each idea was: Will it work, and if it works, is it the most efficient way over a long period of time? Still another consideration was to make each unit simple in operation so that once performed by a new member of the drilling crew it would be easily learned, which was an important item during the manpower shortage.

FIG. 1. E. E. Mosher, tool pusher for Earl Callaway Drilling Company, whose steam rig has been inspected by many South Texas operators as a result of improved layout and design features incorporated under his competent supervision.

Savings of 50 per cent in rigging time and 30 per cent in drilling time made by combining ideas.

The first three problems attacked were simplification of rig layout, unitization of slush pumps and their manifolding, and unitization of boiler feed pumps and their manifolding.

Careful planning preceded the execution of each piece of work to the extent that drilling operations were not interfered with while fabrication was in progress. With Bill Kellog as lead welder and from one to three other welders, the entire work was performed under Mosher's direction at one well location in the field in approximately 15 days. The only shop work performed was the lathe-cut threads on all pipe, which will be discussed later.

The significance of the above facts cannot be appreciated until a personal examination has been made of the precise nature of the high pressure pipe fitting and the close quarters in which ells, tees, unions, and valves have been assembled in the 16-in. space between decks of the boiler feed pump float, yet each valve can be removed instantly for repair.

After being used on seven locations drilling records show that rigging-up time for this steam rig has been reduced 50 per cent and drilling time a conservative 30 per cent, which has more than retired the original cost of construction. It was also asserted that not so much as a union or nipple was changed in rigging-up each time from the original layout, so simple and flexible was the entire setup.

● **Rig layout.** Great care is taken before rigging up to prepare the area for slush pumps and the area for boilers and boiler feed pumps to make them as square and level as the location will permit with the use of a bulldozer. Even hand grubbing is resorted to in order to assure that the 6-in. by 12-in. sleepers will be true and level with respect to the derrick.

All key measurements are taken from the corner leg of the derrick on the engine mud pump sides, the 24-ft. by 35-ft. 8-in. mud pump assembly being 20 ft. from the derrick leg and aligned as shown in Fig. 4.

The two derrick legs parallel to the mud pumps are used to give a working line from which the No. 1 boiler is placed 135 ft. from the derrick and offset 8 ft. The boiler feed pump float is then placed 7 ft. on the opposite side of the working line and the end of the pump house is sighted in with the second row of rivets on the No. 1 boiler. This makes the face of the boilers 15 ft. from the face of the boiler feed pump float and the entire assembly 135 ft. from the derrick.

The two working lines mentioned are sighted in by eye quickly and accurately from the derrick legs and the distances laid off with a 100-ft. tape at the beginning of each rigging-up period. Once these distances have been established on leveled and carefully prepared ground, the work of assemblying the rig equipment is greatly simplified. All other trailer loads of equipment can be spotted and unloaded on final location with the aid of the simple layout drawing supplied each driller. Each piece is always unloaded and placed in the same relative position that it occupied at the last location.

The pipe rack carryall with boiler connections is unloaded within 8 ft. and parallel to the No. 1 boiler. An 8-ft. space separates the combination doghouse-tool house and a large carryall from the boiler connection carryall. Fifteen feet closer to the derrick two 8-ft. by 20-ft. 800-sack mud-and-cement storage houses, separated by a 12-ft. roadway, give ample storage space for these items. Hopper and table are placed within a few feet to the rear of the storage houses and are connected directly to the pumps by piping for mixing mud or cement. A tool house on the far side of the boiler for used materials and a chemical house close to the returns trough complete the covered structures. The sides of all houses between the boilers and derrick are lined up square and level with the straight steam line to the floor and present an orderly and efficient appearance.

Pipe racks are laid out in the conventional manner surrounded by access roads.

● **Slush pump unit.** By comparing Fig. 3 with Fig. 4 many interesting features can be discerned.

The 18-in. by 8-in. by 20-in. slush pump is mounted on a float-type skid

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mounting comprising one trailer load, complete with piping, and measuring 10 in. by 8 ft. by 24 ft. The two 15-in by 7-in. by 18-in. slush pumps are identically mounted except that the float width has been reduced to 7 ft. 10 in. All three floats are constructed of 10-in. by 10-in. 45-lb. H-beams with cross members of the same material. Top and bottom is decked solid with ¼-in. sheet steel and the ends are rounded off with 8-in. 36-lb. casing to aid in loading.

Four spacers 10 in. by 3 ft. by 24 ft. and constructed of the same material separate the three pumps and provide a walkway around the outside edge of the assembly.

Each pump float has a 2-in. angle iron alignment notch on both sides to which a spacer fits snugly with a corresponding male Vee, assuring identical positioning with each new set-up.

Leveling plates have been welded to each end of the pump floats and spacers that hold the 7-piece unit to the established grade.

To assemble the unit, three 6-in. by 12-in. by 36-ft. sleepers are placed on the site for the slush pumps and carefully leveled. The 18-in. by 8-in. by 20-in. pump is unloaded on the sleepers and snaked into alignment with the derrick leg as shown in the drawing. Once this piece is in correct position, each spacer and pump unit can be unloaded and drawn up snug with the use of winch lines. The 6000-lb. hammer unions on all piping crossing the floats are made up at each joint and the result is a rigid, stable, pumping unit measuring 24 ft. by 35 ft. 8 in.

All water, steam, and mud piping is mounted permanently on the assembled units by means of welded brackets to the top decking of the individual floats. Unions are placed at each point where piping crosses to an adjoining float and where supply or discharge lines approach or leave the unit.

All 4-in. piping was fabricated from 16.6-lb. drill pipe with welded and threaded connections. Threaded nipples have lathe-cut threads with the inside edge chamfered on a 1¼-in. taper to insure life by eliminating swirling and cutting out by abrasive fluids. To insure safe operation at high pressure over a long period of time 6000-lb. valves and unions were used throughout.

Piping of 3 in. diam. used in the compound lines was also made of 16.60-lb. drill pipe and is equipped with 4000-lb. valves. All 2-in. lines are external upset end tubing with 4000-lb. valves.

Where piping and valves are concentrated in the decking, removable cover plates have been provided to assure adequate walking room and a floor space free of objects on which a workman might trip.

The use of high pressure pipe and fittings throughout the assembly insures a high operating efficiency and flexibility with a minimum of down time. Alternate pumping routes have been provided when inevitable shut downs do occur as will be noted by the two 4-in. lines to the standpipes and rotary hoses. Each pump can be cut out or in as occasion demands and from one to three pumps can be compounded to pump water or mud at high pressures anywhere in the vicinity of the rig. Any part of the manifold can be shut down for repacking and repairs without interfering with drilling operations. It is even possible to compound two boiler feed pumps into three compounded slush pumps if necessary.

Direction of pumping operations is under the immediate supervision of the driller who has instant control over all pumps by means of the valve extensions to the derrick floor. All parts of the assembly are within his visual range, making it possible to spot trouble quickly.

Cementing and service companies serving the rig take one look at the high pressure set up and proceed with their operations with confidence that it is safe at any pressure they are likely to use.

Mud mixing is made easy by three mud guns mounted on the far end of the pumping assembly in easy range of the slush pit, which is always placed against the end of the pumping assembly. Suction lines from the pumps are operated by windlass over the end of the floats.

An interesting device has been made to stir up settled particles of mud and to provide prime on the large suction hose extension pipe when the pumps have been shut down for some time. Water pumped from the boiler feed pumps can be jetted into the suction line by means of the 2-in. header and 1-in. jets welded in at a 45-deg. angle for that purpose. One set of jets is provided for each suction pump.

FIG. 2. The systematic arrangement of houses between boilers and derrick is planned to place mud storage houses close to hopper and table and to place stored repair parts conveniently near to both derrick and boiler machinery.

● **Shale shaker and returns ditch.** The steam-operated shale shaker is unitized with a chemical tank of two compartments having a capacity of 2 bbl. each. This is directly over and welded to the first section of 24-in. diam. steel mud ditch. The mud ditch is constructed of 24-in. 50-lb., conductor pipe in three 20-ft. sections, the first section being welded to the shale shaker and chemical tank. The third section is attached to the derrick whereas the second section drops into place between the end sections and rests without the aid of bolts on half-round lips welded to the two outer sections. Two 18-in. by 8-ft. holes are cut in the top side of each section to allow visual inspection of the mud flow at all times. The entire assembly rests on 2-in. pipe standards, and angle iron brackets on either side of the conductor pipe support the four 2-in. by 12-in. walkway timbers.

● **Boiler feed pump assembly.** Three boiler feed pumps, feed water heater, generator, and firing controls are housed in a float-type structure with a light steel housing over all. The entire assembly is one trailer load measuring 7 ft. 10 in. by 35 ft. by approximately 8 ft. high. Two 8-in. by 16-in. I-beam runners frame and support the floor with 10-in. pipe to round off the ends. The bottom is sheeted with ¼-in. steel plate and the top side decked with 5/16-in. diamond floor plate. The house frame is of 2-in. piping for

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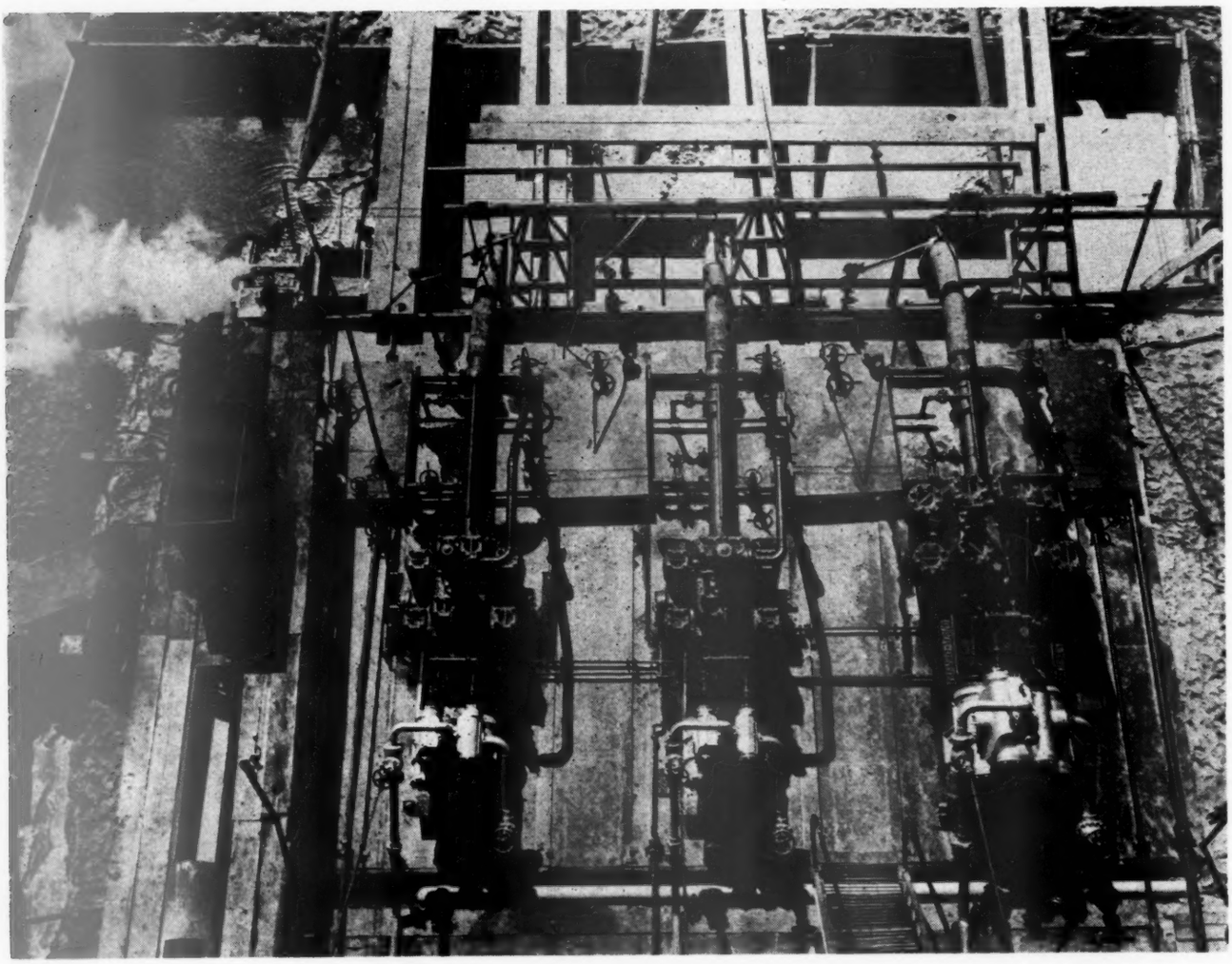


Fig. 3. This overhead view of the slush pump arrangement shows the compact placing of the three pumps with ample walkway for repacking and adjustment purposes. Comparison with the diagram in Fig. 5 will show many interesting details.

corner and center posts with 1/16-in. sheet steel on ends, sides, and roof.

Two hinged floor extensions, one 5 ft. on the boiler side and the other 3 ft. give a total extended floor space of 16 ft. when lowered to rest on their angle iron supports. Roof is also provided with two 5-ft. drop sides that afford weather protection for a total of 18 ft. The triangle supports swing inward under the main roof when the unit is reduced to trailer load for moving.

All piping is compactly arranged below the top decking and above the bottom sheeting with removable cover plates over each valve cluster. The unit can be supplied with water, gas, or steam from either end by union connections. Connecting points not in use are blocked off.

Suction lines to the three pumps are two 4-in. hot and cold water lines running the length of the unit and tied in to each pump, the hot water coming from the feed water heater. As these suction lines are also used for compounding any two pumps, 16.60-lb. drill pipe has been

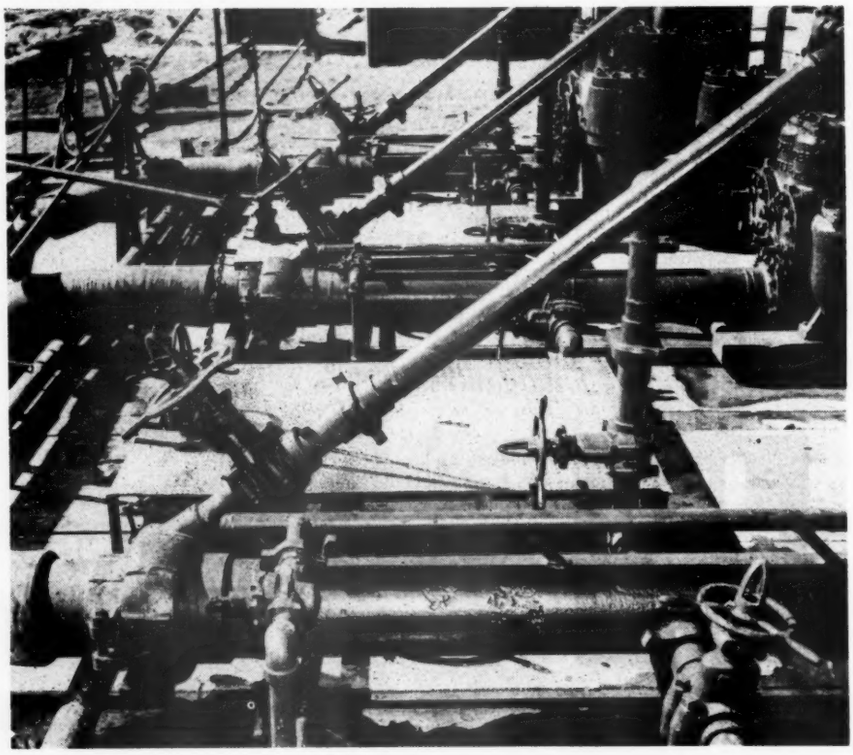


FIG. 4. Piping arrangement of the three slush pump units is flexible in operation for all pumping and well servicing needs.

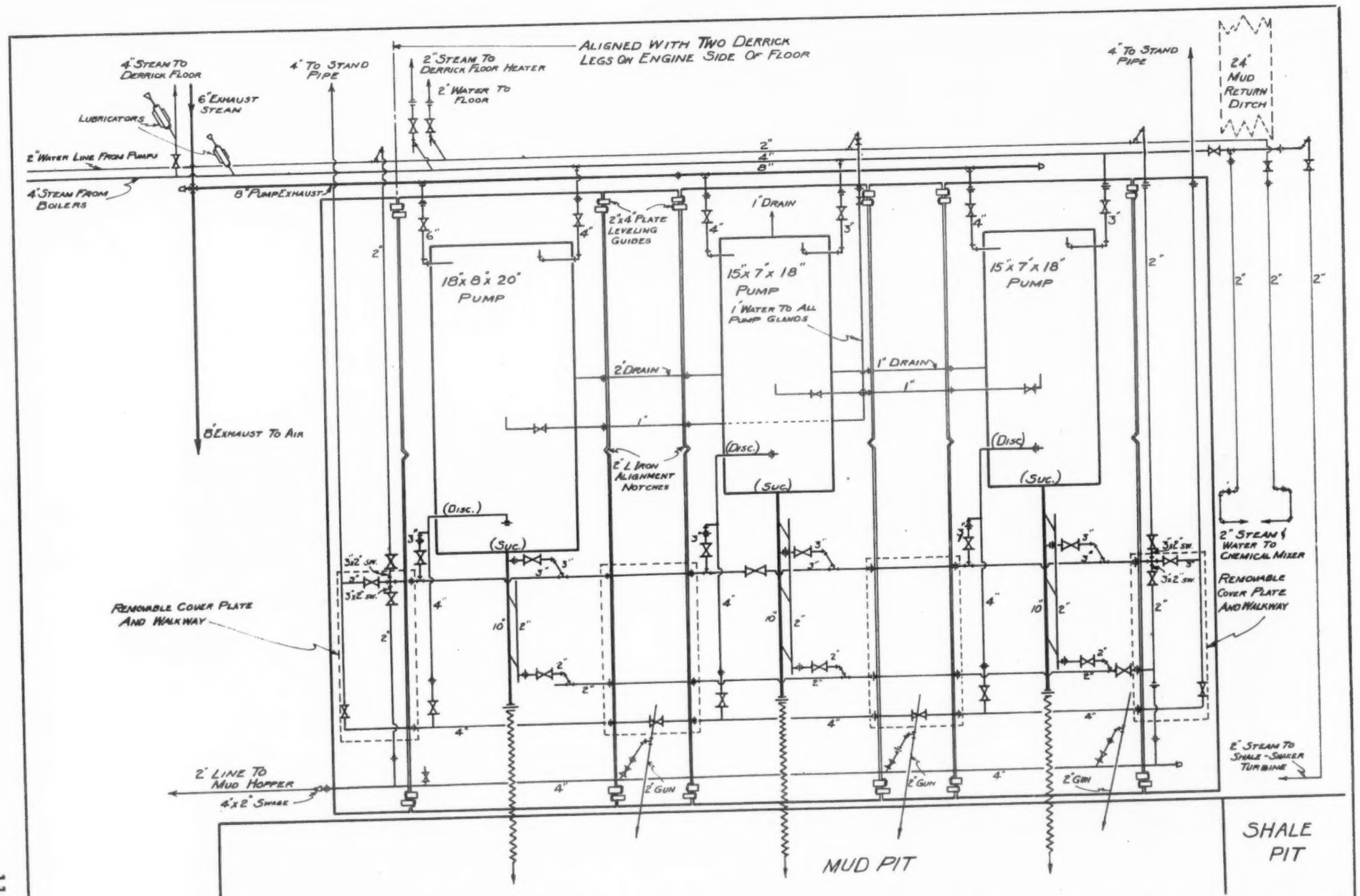


FIG. 5. A diagram of the suction and discharge piping to the slush pumps shows the 1-in. jets welded into the suction line for stirring up settled particles after long shut-down period.

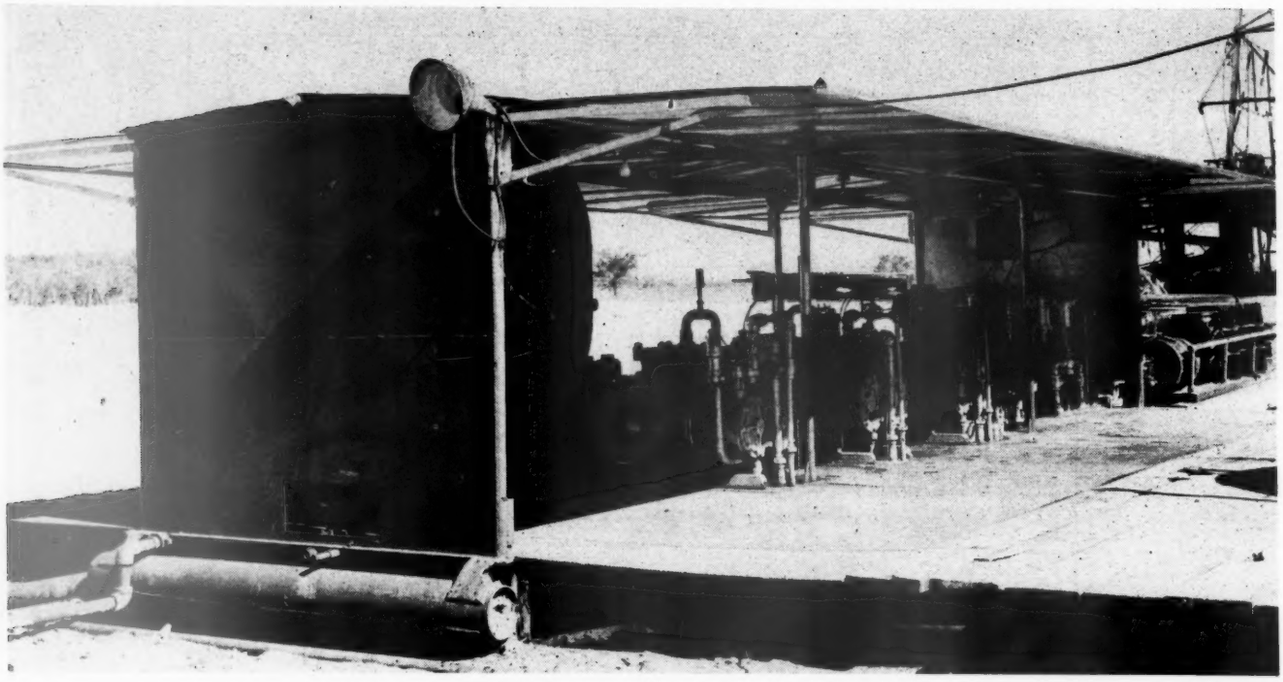


FIG. 6. Boiler feed pump float and house have floor and roof extensions that fold to make a trailer load 7 ft. 10 in. by 35 ft. by 8 ft. high.

used. Suction valves are flanged plug valves, bar operated, and are installed for quick removal and interchangeability if necessary.

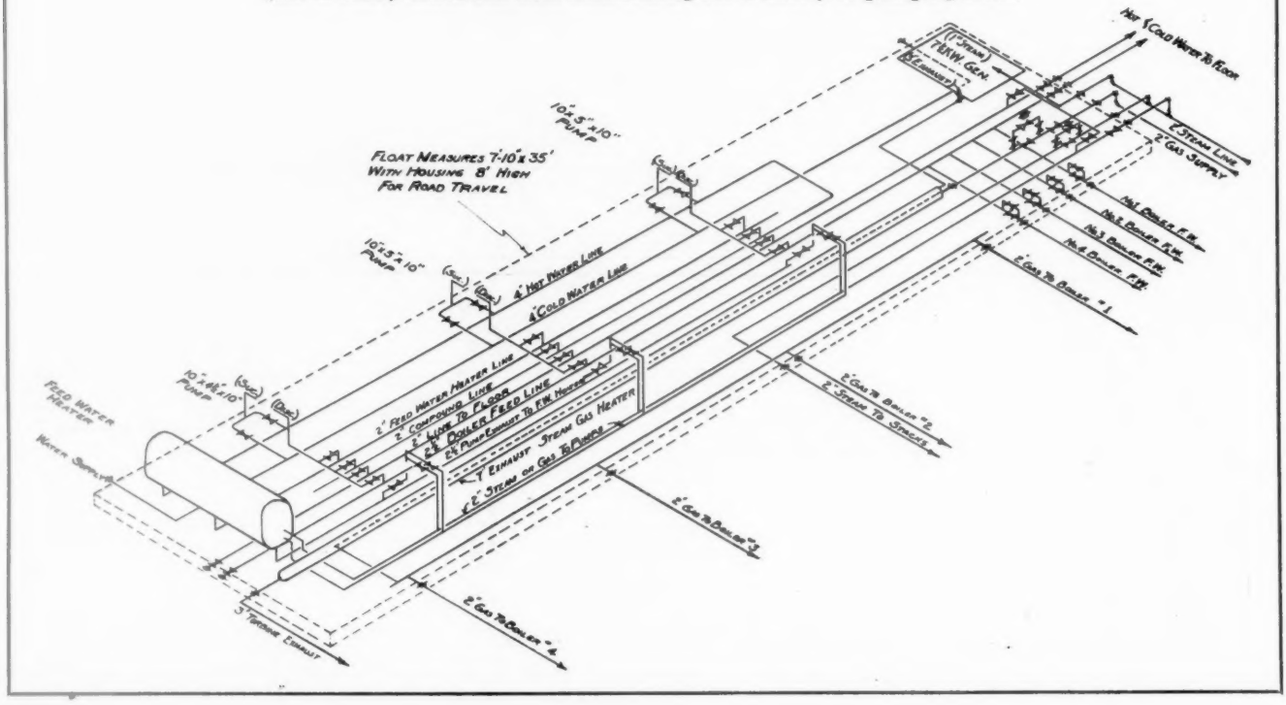
The 4-valve discharge manifold is equipped with 2-in. 2000-lb. valves with hammer unions welded to both sides for ready removal in case of leaks. The 2-in. piping is external upset tubing cut and welded to fit where needed. Four 2-in. discharge lines are provided, one to the boilers, one to the derrick floor that is also tied into the slush pump manifold, one to the feed water heater, and the fourth is used to compound any two of the three pumps while the third is on boiler feed duty.

A 30-ft. joint of 7-in. 26-lb. casing runs the length of the float for the purpose of surge and heating space for gas to the boilers. Gas is heated with generator turbine exhaust steam by means of a 30-in. line running concentric with the 7-in. casing and sealed off at the ends to form a heating chamber.

Gas to the boilers is automatically controlled by a removable diaphragm-type control valve as is the case with the steam to boiler stacks.

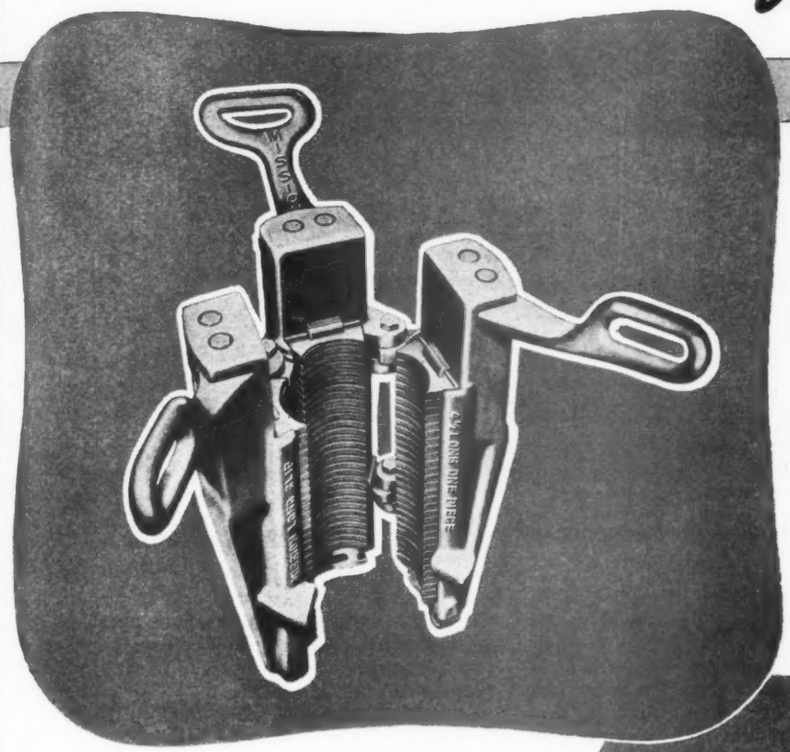
An adjustable choke valve is used in conjunction with a regular 2-in. valve to regulate feed water to each boiler. The 2-in. valve allows the bulk of the water to pass and the choke permits fine adjustment not otherwise possible by manual regulation. Bonnets of all four chokes are above the floor and can be backed off readily should wear or foreign matter interfere with their proper operation; however, the elevated posi-

FIG. 7. Diagrammatical sketch of boiler feed pump piping arrangement (not to scale) shows sub-floor manifolding for a variety of pumping tasks.


FLOAT MEASURES 7-10 X 35' WITH HOUSING 8' HIGH FOR ROAD TRAVEL
10" X 5" X 10" PUMP
10" X 5" X 10" PUMP
10" X 6½" X 10" PUMP
4" HOT WATER LINE
4" COLD WATER LINE
2" FEED WATER HEATER LINE
2" COMPOUND LINE
2" HOT TO FLOOR
2½" BOILER FEED LINE
2½" PUMP EXHAUST TO F.W. HEATER
2" EXHAUST STEAM GAS HEATER
2" STEAM OR GAS TO FLARE
FEED WATER HEATER
WATER SUPPLY
3" TURBINE EXHAUST
2" GAS TO BOILER "4"
2" GAS TO BOILER "3"
2" GAS TO BOILER "2"
2" STEAM TO STACKS
2" GAS TO BOILER "1"
2" GAS SUPPLY
2" STEAM LINE
HOT WATER TO FLOOR

Save drilling time and protect your drill pipe, casing and tubing with

MISSION *Rolling Dog* SLIPS



Mission's Famous *Rolling Dog* Construction

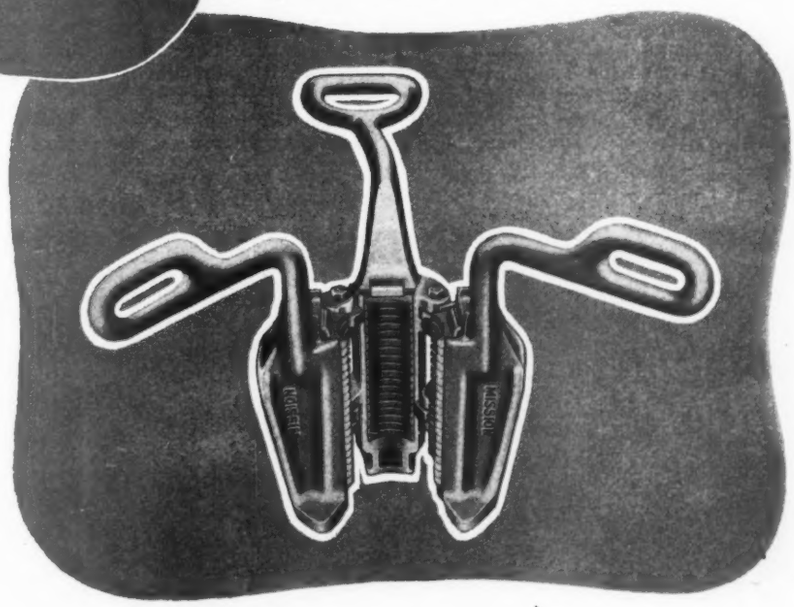
consists of a stack of pipe-engaging dogs with rounded backs to permit them to roll.
This unique construction assures:

Positive Grip

When slips are dropped in bowl, the dogs roll upward slightly. When the load is being taken by the slips, the dogs roll downward to grip the pipe firmly.

Instant Release

When the load is being taken off the slips, the dogs roll upward and away from the pipe — releasing the pipe and freeing the slips from the bowl.



The positive gripping and instant releasing due to Mission's rolling dog construction means: No coaxing the slips to take hold. No struggling to get them to release. **Assures safer, faster round trips.**

There is a set of Mission Slips designed especially for your rotary and your practice. From the largest casing slips and extra long rotary slips to the smallest tubing spiders, Mission builds slips to fit your needs.

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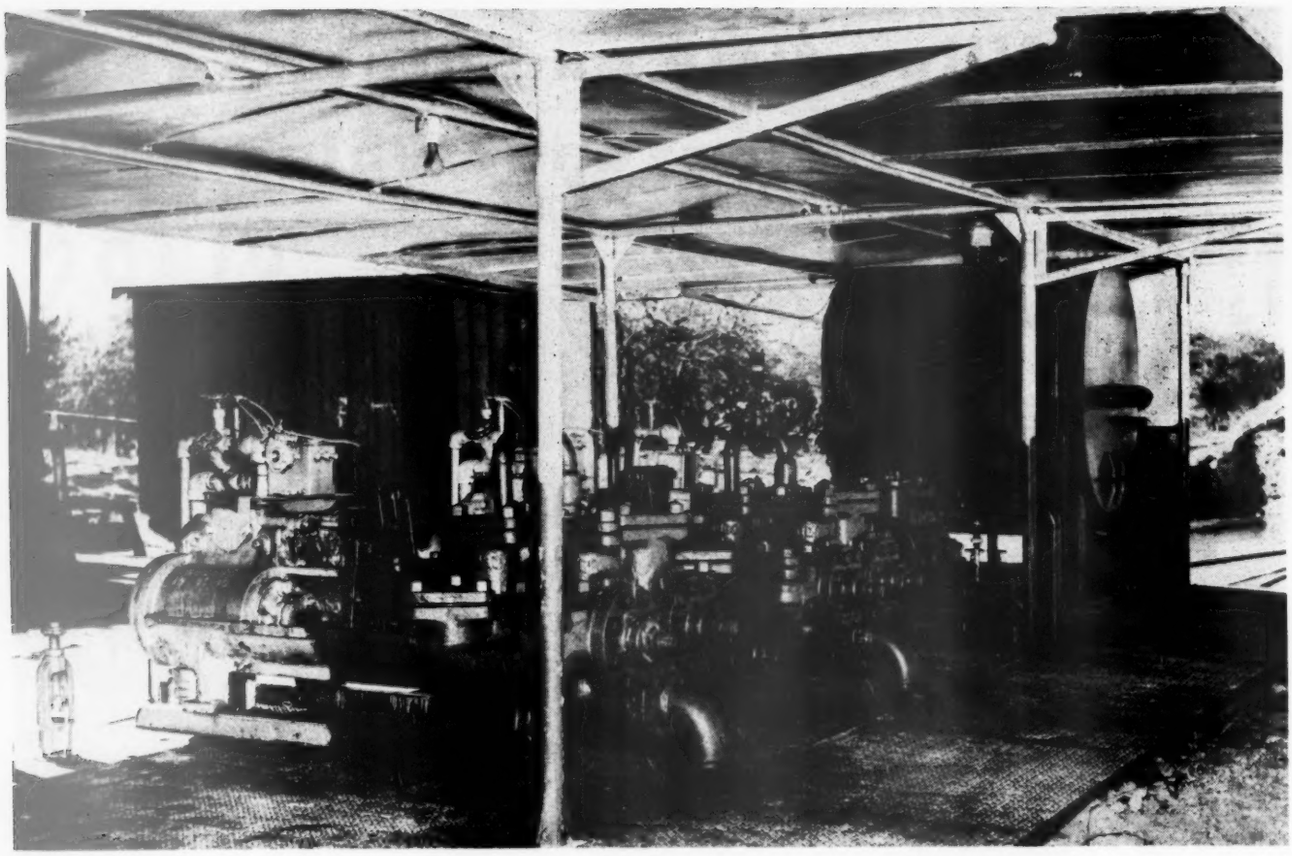


FIG. 8. All suction and discharge piping is between the bottom sheeting and top decking of the 16-in. I-beams.

tion and flame-hardened points and seats of the chokes have given continuous service over a period of 9 months with no sign of wear.

A combination gas and steam line of 2-in. pipe extends the length of the float with risers to each boiler feed pump. The end of the line enters the feed water heater by way of a 1-in. float-operated control valve and is piped back to all three feed pumps. Any pump selected to supply the feed water heater is thus controlled by the heater. The other two pumps take their steam from the line before it enters the feed water heater control valve.

Should the pumps be gas operated instead of with steam, the same line can be used to supply gas to the steam chest with the feed water heater control cut out of the system. Both risers to the feed pumps can be seen in Fig. 6.

All gas, water, and stack lines to the boilers are interchangeable with no left or rights that have to be marked before moving.

The extreme flexibility of the high pressure piping and valve arrangement allows for just about every conceivable pumping task that might occur. Gas, hot water, and cold water can be delivered to boilers, derrick floor, or slush pumps with equal ease. When the "No Fire" order goes up, pumps can still be operated with gas instead of steam. This permits boilers to be filled cold when there is no steam at hand. Gas can be taken from outside sources or from the derrick floor and boosted in pressure to be returned to the derrick floor or to any other point by compounding the boiler feed pumps.

It was interesting to note that the crews on this rig went about their work with a sense of assurance and a general feeling of personal safety that added much to the overall efficient operation of the rig. Each man knew exactly where to find the valve needed to accomplish each operation because that valve was always in the same place after each change of location. He also knew an alternate method of accomplishing each task, should some piece of equipment fail. ★ ★ ★

FIG. 9. Steam, gas, and water connections are at either end of float.

PACKAGED TYPE DEHYDRATION PLANTS

By **H. F. DAWE,** The Stearns-Roger Manufacturing Company

Unit is of value to natural gas industry for use in fields of limited production.

EXCLUSIVE

RECENT conservation measures in Gulf Coast states and the commercial possibilities of natural gas sales to pipe lines have been combined to increase the interest in small fields producing from a few to 20 and more million cubic feet per day. Generally, before this gas can be commercially disposed of to pipe lines it must be dehydrated to meet pipe line specifications. These specifications vary, but generally the dewpoint required is somewhere near 32°F. and below, particularly when the gas is to be transported into northern states.

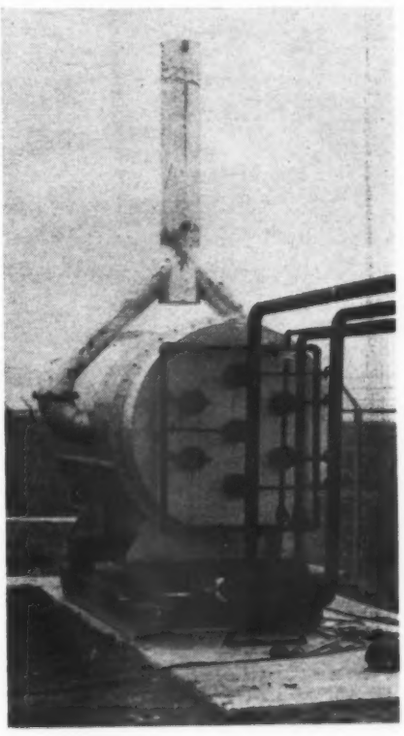
Dewpoints above 32°F. can be obtained readily by use of diethylene glycol dehydration units. Such plants have been made in sizes to handle from a few hundred thousand cubic feet per day to hundreds of millions cubic feet. Generally, they are almost entirely automatic and require but little operating attention. This fits particularly well into an operating setup where operating personnel is always close if not in constant attendance. As the process is a continuous one of absorption, it is entirely satisfactory for the dewpoint requirements and may be made almost foolproof. There are features, however, such as operating machinery pumps, etc., that must be gas-gasoline engine driven or driven by electric motor. An operating drawback is the fact that an operator must be in part-time attendance at each plant. This increases the cost of operation and indicates that some thought must be given to the personnel angle before building a unit, especially one remotely located.

When it is impossible to meet pipe line specifications with glycol or similar plants, or it is desirable to install a virtually automatic plant requiring a minimum of attention, a dehydration plant employing a granular adsorbent is indicated. There are many successful commercial granular adsorbents on the market today and all are being employed in plant scale work dehydrating natural gas.

Careful analysis of the desirable engineering characteristics of a granular desiccant indicates that resistance to fouling, resistance to poisoning, high crushing strength, adequate mesh size, low pressure drop, physical stability, high adsorptive capacity per unit volume, low regeneration temperatures, long operating life, and low initial cost are most important. Large adsorption capacity results in a smaller and more compact unit, more easily handled in the field and generally less expensive. Particularly of interest in smaller plants of the size mentioned is portability, for the field may not be commercially profitable for a long period, or due to a change in planned operation other uses may be devised for the gas. Units may be devised that have especially high salvage value and may conveniently be erected, dismantled, and moved using conventional oil field equipment. The unit may be shop built and preassembled and then dismantled ready for easy field erection with a minimum of effort and equipment. This feature has resulted in describing such units as "packaged" plants.

In the construction of small plants, it appears generally acceptable to design a plant of such capacity that it must be

Present heater for package-type dehydration plant.



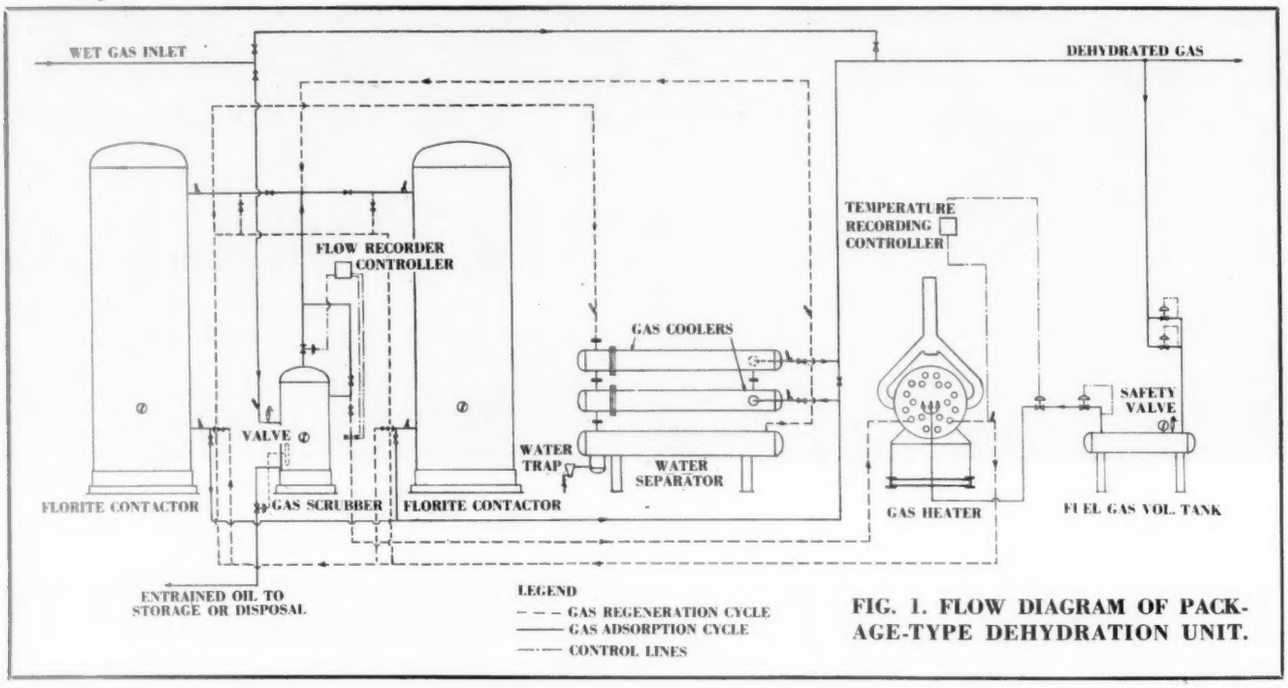
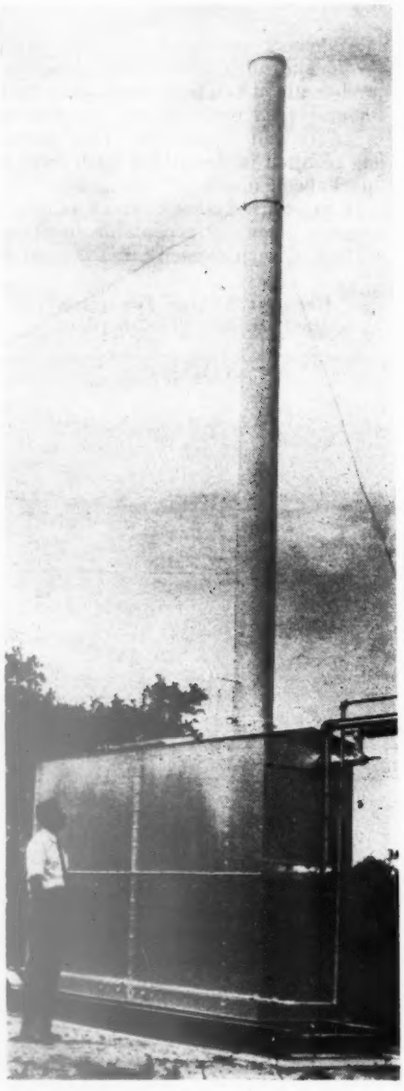


FIG. 1. FLOW DIAGRAM OF PACKAGE-TYPE DEHYDRATION UNIT.

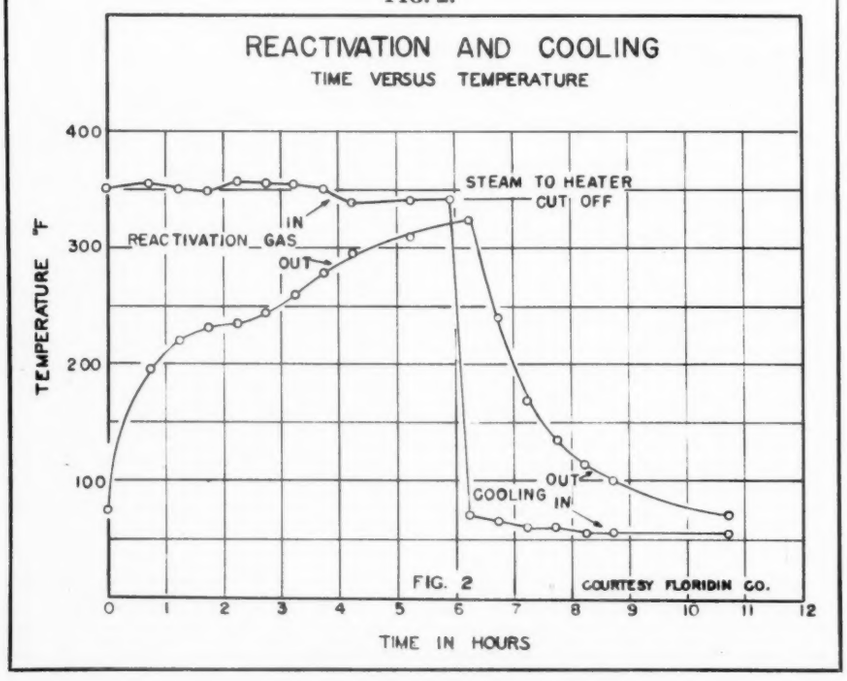
Experimental heater, showing base.



attended only a minimum amount of time and during regularly established tours of the producing area. Generally, such tours call for a maximum lapse of time between checks of not more than 24 hr. and usually less. The design time-relationship appears to be best based, therefore, on a 24-hr. cycle. This may be attained by use of a 12-hr. adsorption period, 6 hr. or so regenerating and the remaining 6 hr. devoted to cooling. Necessarily this brings two chambers, containing the adsorbent, into use for continuous operation over the 24-hr. period, and this cycle allows one chamber to be on stream at all times while the other chamber is regenerated and cooled for subsequent adsorption. To render the unit as free as possible from moving parts and attendant trouble, maintenance difficulty and expense, the unit must not employ regeneration systems requiring blowers or compressors. It must also be free from requirements for cooling water, cooling water towers, pumps, etc.

Many granular adsorbent plants have been built requiring the use of low pressure heated gas for regeneration by reversed flow. Usually this involves operation of blowers or compressors or the use of an auxiliary low pressure gas stream. This may be satisfactory where the low pressure gas may be used fur-

FIG. 2.



ther, as for fuel, etc., without the necessity of additional compression. Where natural gas is available at a pressure greater than pipe line requirements, it is possible to regenerate by using a drop in pressure of the regenerating gas. Units may be so designed as to be completely free of all moving machinery, utilizing gas differential pressure entirely. The flow diagram for such a plant is given in Fig. 1. Fortunately, many fields are produceable under such conditions. The flow diagram illustrates a plant having two adsorbent chambers, wet gas scrubber, a direct gas fired regeneration gas heater, gas coolers, water separator, and necessary auxiliary equipment.

Referring to Fig. 1 it will be seen that the entering wet gas is introduced through a pipe line into a scrubber where entrained liquid is removed. The scrubber is important, for the plant may produce considerable liquid hydrocarbons that, if it entered the contactor chamber, would render the granular absorbent considerably less efficient in the matter of adsorbing water vapor. At the outlet of the scrubber there is placed a motor control valve. This valve operates in the main wet gas stream to the contactors at any established flow rate of regeneration gas by throttling the main gas stream. The action takes place through a flow recorder-controller operating on the regeneration gas stream. The wet gas enters the chamber on adsorption in the cycle, and flows downward through the granular adsorbent and out the bottom of the contactor directly into the pipe line. Downflow is important, for the flow tends to hold the adsorbent on the beds. Upflow through the beds in adsorption may blow the adsorbent off the bed, and result in channeling even though upflow velocity does not exceed that in downflow.

Gas for regeneration purposes is taken as a sidestream from the main wet gas stream where it passes through the direct gas-fired regeneration gas heater and into the bottom of the contactor being regenerated. The hot regeneration gas passes upward through the chamber on regeneration, and as the temperature of the bed is raised the water vapor is carried from the chamber. The hot wet regeneration gas stream is introduced into

PACKAGE-TYPE DEHYDRATION UNITS.

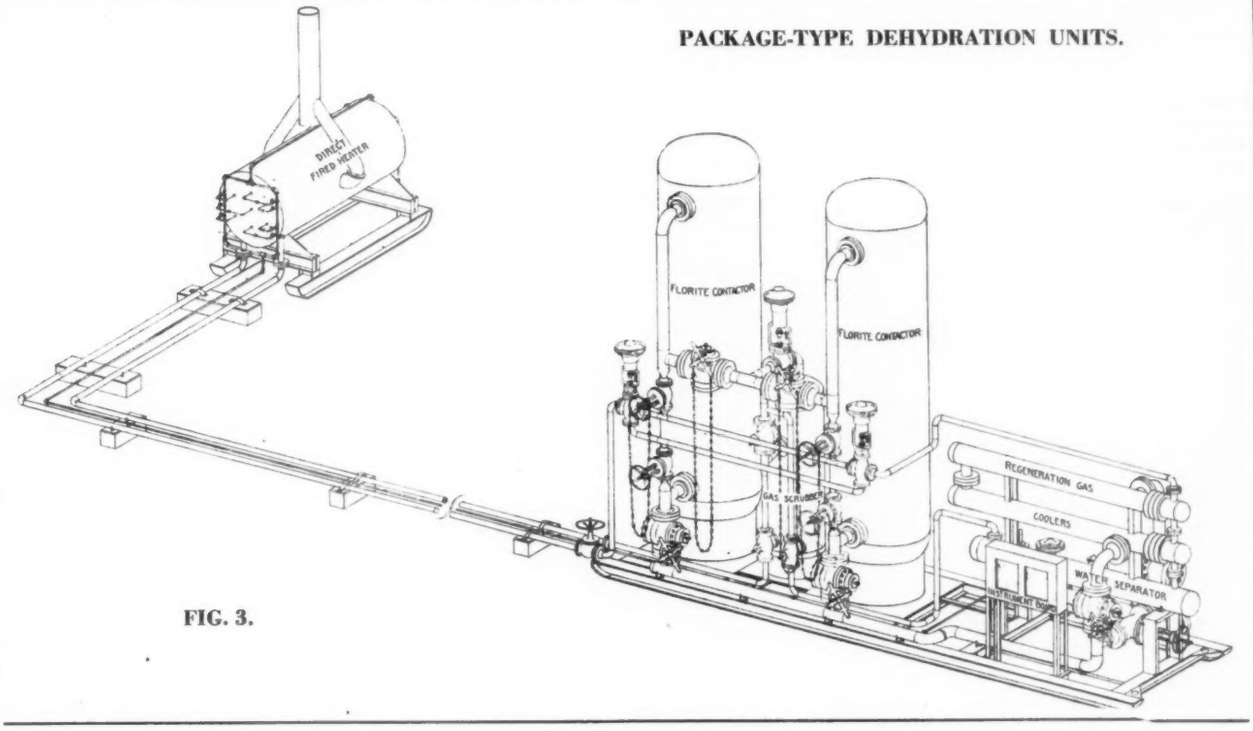


FIG. 3.

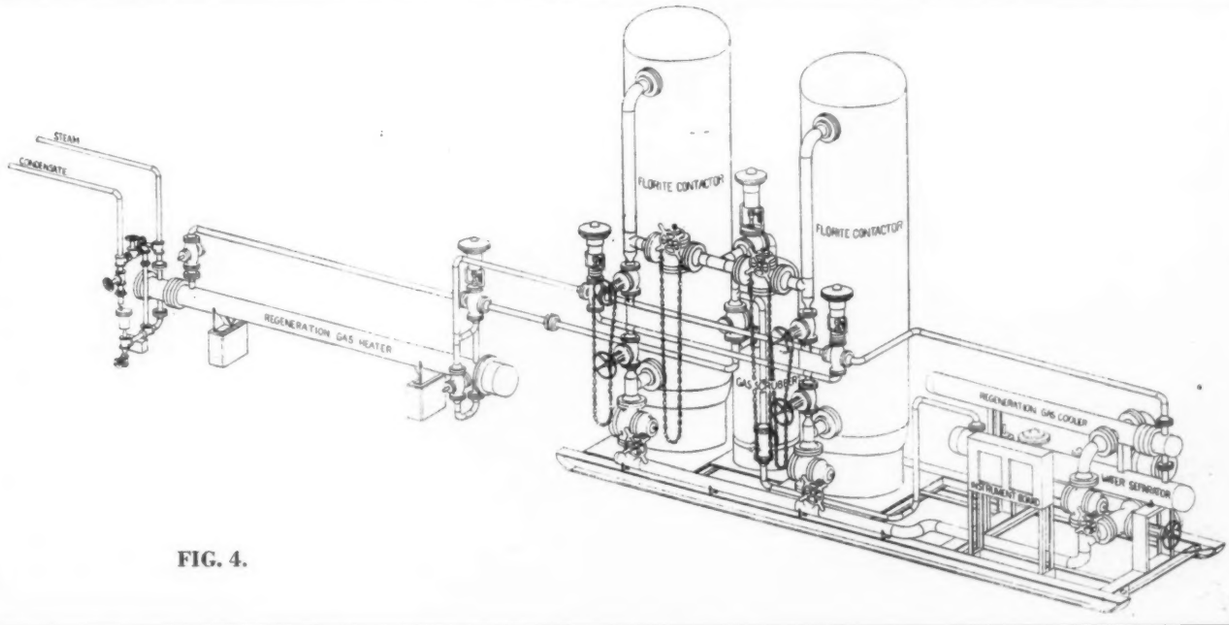


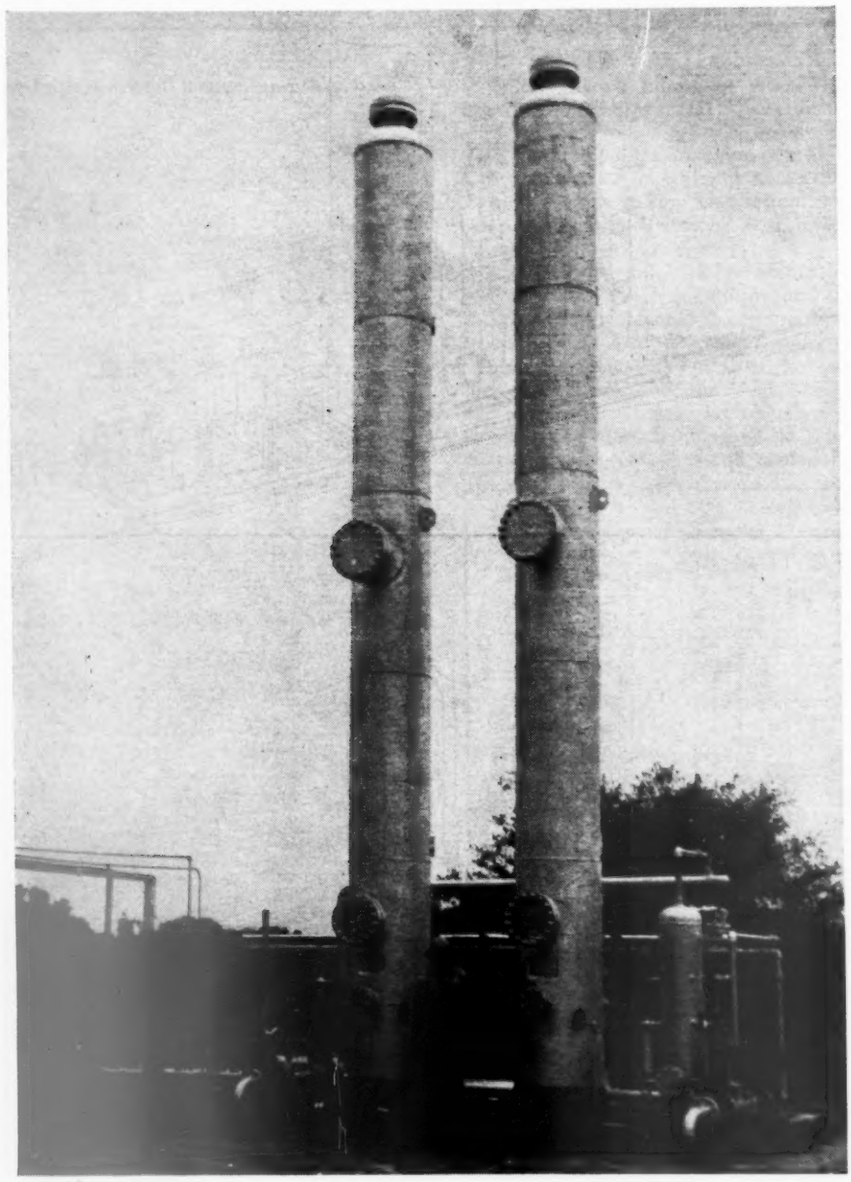
FIG. 4.

a shell-and-tube heat exchanger where it is cooled about 200° F. and the condensed water vapor is removed. The active exchange cooling medium is the main cold stream of dehydrated gas. It will be noted from the diagram that a bypass valve allows any required portion of the main dry gas stream to serve as the cooling medium. The condensed water drops out into a water collector chamber or separator where it is trapped and blown from the system. The cooled regeneration gas then flows back into the main wet gas stream and is dehydrated as part of the main gas in the chamber on adsorption.

To control the regeneration and cooling cycle, it is necessary that the regeneration gas temperature be controlled. Experience indicates that regeneration of a chamber is substantially complete when the regeneration gas stream reaches a temperature of about 300-350° F. Regeneration at this temperature is accomplished in a period of 6 hr., by choosing a regeneration gas flow of proper quantity. Fig. 2 indicates the reactivation curve period, and shows that the chamber may be considered regenerated when the inlet and outlet gas temperatures are about the same. A temperature recorder controller shuts down the heater when the temperature indicates regeneration has been accomplished. The regeneration gas stream then flows unheated through the regenerated chamber but in a reversed direction. The reversal is accomplished by use of three-way motor controlled valves.

TABLE 1. Typical dehydration plants.

Quantity of gas, cu. ft. per day	Operating pressure, lb. per sq. in.	Diameter of towers, in.	Height of towers	Number of towers	Desiccant per chamber, lb.
20,000,000	1000	60	15 ft.-6 in.	2	10,000
20,000,000	1000	60	15 ft.-6 in.	2	10,000
20,000,000	800	54	18 ft.	2	10,000
20,000,000	800	54	18 ft.	2	10,000
20,000,000	700	60	15 ft.-6 in.	2	10,600
10,000,000	800	30	29 ft.	2	6,000
10,000,000	800	30	29 ft.	2	6,000
1,000,000	600	30	13 ft.-6 in.	2	2,400



Experimental package-type plant constructed for Tennessee Gas and Transmission Company, showing contactors and other equipment on base.

The cooling period occupies the remaining 6 hr. of the cycle, and at the end of that time the chamber is cooled to main gas temperature, and is then ready to be placed into adsorption service. The switch in chambers is accomplished manually by reversing the main and regeneration gas valves to each chamber. The heater instrument is reset and the heater relighted by a pilot. The cycle is then ready to be repeated. This work is done or may be done by the operator on his regular tour.

The cycle change could be made completely automatic from every standpoint by use of timing devices. It is considered advisable, however, to require some operator attendance at predetermined intervals. This is necessary in any case for chart change and instrument check. It requires about 30 min. of operator time to switch chambers and change the chart records.

In order to make these units as compact as possible, they have been mounted upon structural steel frames. One frame serves as a base for the two contactors, the scrubber, cooler, water separator, gas volume tank, and instrument board. The structural steel base under this equipment rigidly contains these items and allows more complete use of prefabricated piping. The unit is too large and heavy to be transported any distance except by removing the chambers from the base. The rest of the equipment may remain on the base, which is of such size that it may be moved on an oil field float. The assembled unit may be skidded to a new position over good ground by use of a tractor. The heater may be hauled or skidded without dismantling. The structural steel bases may be set upon simple concrete sleepers, which may be precast and of such size to provide proper bearing. A concrete slab may be poured to support the main unit, and no foundation or hold-down bolts are required. For safety reasons the heater is mounted away from the rest of the unit upon a separate structural steel base. All main unit piping is mounted at the unit, and all heater piping is mounted at the heater. The interconnecting piping may be installed as desired.

A variation of the unit is shown in Fig. 4 where steam is used to heat regeneration gas. This is only possible where there is steam supply available.

Experience in the construction of many of these units indicate that units of the sizes shown in Table 1 may be moved to a job site, assembled for operation, and insulated in place in a period of less than one week when prefabricated in the shop. ★ ★ ★

P 615.91

NEW PROBLEMS PRESENTED BY SUBMARINE PIPE LINE

By **RICHARD SNEDDON,** *Pacific Coast Editor*

EXCLUSIVE

BATTLING swift running tides, sub-surface coral reefs, and the unpredictable temper of the waters of the Persian Gulf, Bechtel McCone Corporation, constructors, and engineers of Standard Oil Company of California, using all their ingenuity, not only completed the laying of a 17-mile 12-in. submarine line from the mainland of Saudi Arabia to the Island of Bahrein, but came within one day of predicting exactly when the job would be finished. Ninety days was the estimate of the engineers; 91 days it took to finish the project (only 65 of them working days), and by a peculiar turn of circumstance no sooner had the last section of pipe been tied into place than there broke loose the worst storm of the season just to test the endurance and general stability of the line.

The submarine portion measured about half of the 34-mile line that was projected for the purpose of bringing oil from the wells of the Arabian American Oil Company in Saudi Arabia to the island refinery of the Bahrein Petroleum Company, in both of which Standard of California owns a 50 per cent interest. The entire program was planned to eliminate the necessity of shipping oil across the strait by barge, a somewhat inefficient process the limits of which were definitely in conflict with the increasing requirement of the Bahrein refinery. In addition to the 17 miles of line over the Gulf, the construction involved the laying of 10.6 miles across Bahrein Island, and 1.6 miles in Saudi Arabia to tie into an existing pair of 6-in. lines each 5 miles long.

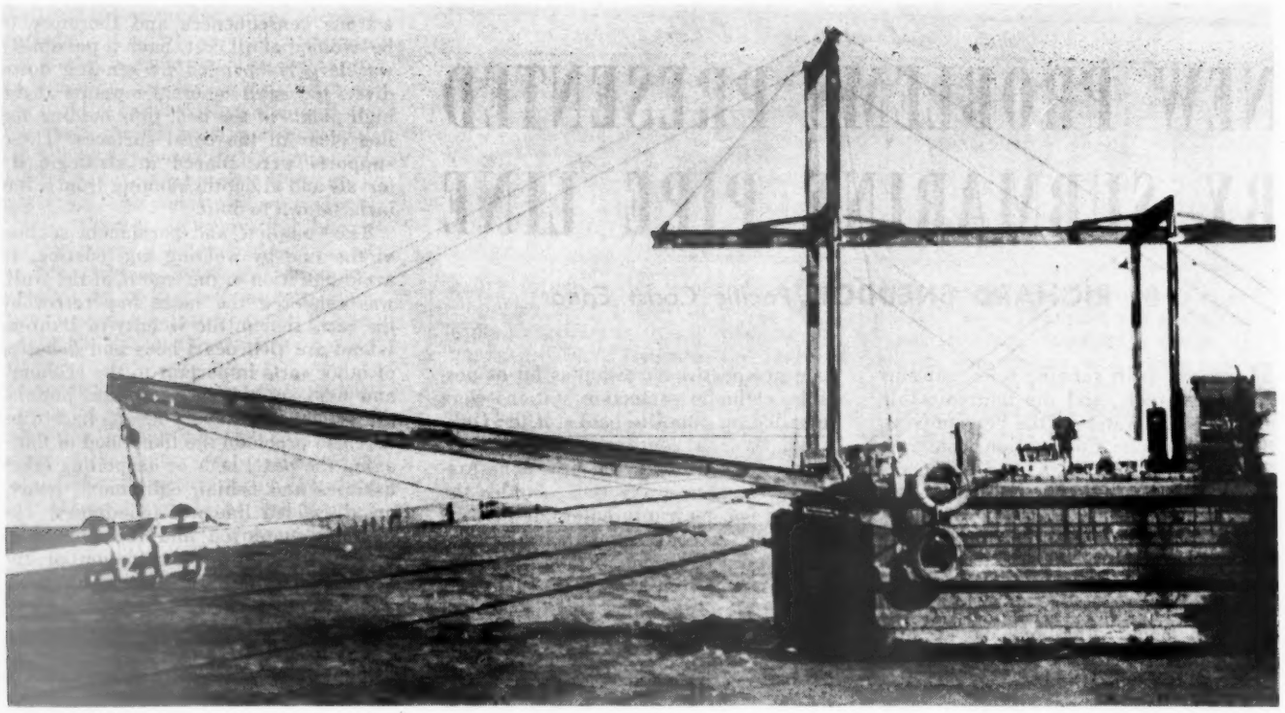
One of the many deleterious influences that the constructors had to combat was corrosion in an unusually virulent form. The waters of the Persian Gulf carry an abnormally high concentration of salt, and reach a temperature well above 80°F. in the summer months, a combination against which it was necessary to provide adequate protection. This was done by sealing the entire length of the submarine line off from all direct contact with the water. Each section of pipe was given a thick sheathing of Somastic pipe coating, a product developed by Standard Oil Company of California and manufactured under license by Industrial Engineering Corporation. It is composed of asphalt, graded sand, and asbestos fibers in intimate admixture. After the sections were welded together, the weld area was also coated, and to eliminate prospective corrosion as far as possible, cathodic protection stations were installed on opposite banks of the Gulf. From these a continuous electric current is sent through the pipe thus providing further protection should the coating become ruptured at any point.

The latter contingency was one that presented a distinct hazard. In fact, the hazard involved more than the mere possibility of a damaged coating. In the first place, the bed of the strait in the immediate path of the line was interspersed with numerous coral reefs or shoals, some near the surface, some at greater depths, and most of them separated by deep channels. Any movement of the pipe against these jagged coral formations was likely to result not only in stripping off the protective coating and leaving a section of the line exposed to the corrosive medium, but might actually have the much more serious effect of puncturing or breaking the line—an accident that could precipitate disastrous consequences and therefore to be avoided at all cost. Such a possibility was largely obviated by sending down divers to install concrete supports at the high points of the bed, thus holding the line clear of the coral surfaces. These supports were placed at strategic intervals and at depths ranging from a few inches down to 50 ft.

The complete and permanent sealing of the line by welding and coating, to avoid pollution of the waters of the Gulf, was rendered the more imperative by the facts that in the vicinity of Bahrein Island are rich pearl beds and fisheries of other sorts important to the economy and food supply of the coastal populations. Obviously, every means had to be taken to preclude the likelihood of damaging the pearl beds or despoiling other fisheries and fishing equipment, hence, an all-welded line was mandatory. The methods employed and the difficulties encountered in the completion of the project are both interesting and instructive because they required the exercise of considerable engineering skill.

Before construction was begun, the primary field maneuver with respect to the submarine section of the line was a careful hydrographic survey of the area between the island and the mainland. In this manner the best route for the line was selected and marked by driving piles at about 1100 ft. intervals, so that the pipe-laying barge could later follow

Somastic field joint applied to pipe line laid in strait between Bahrein Island and Saudi Arabia coast.



Roller assembly keeps pipe from sagging.

readily the chosen course. These piles also served as anchors to secure cables with which the barge was held in place fore and aft, or moved along by winches located on the deck. Regular deep sea anchors controlled the lateral movement of the vessel. Fast running tides and sporadic storms necessitated the observation of every precaution to prevent the barge from drifting off her course.

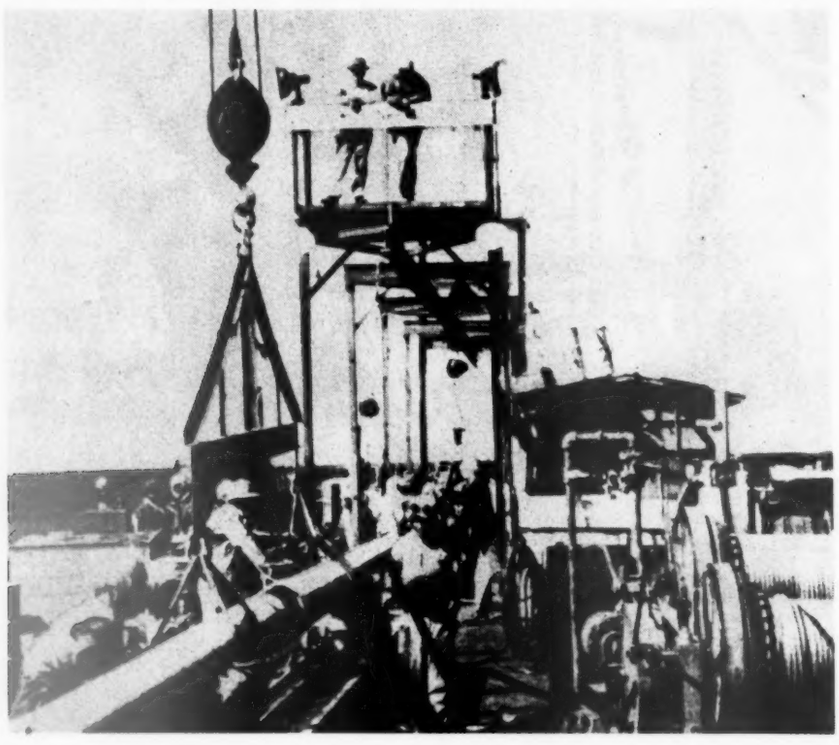
The adoption of welded construction for the line imposed certain engineering obstacles that were eventually overcome, but are nevertheless worthy of some discussion. The welded joints were no less rigid than the line itself, which meant that as newly welded and coated line was paid out over the stern of the barge it could be bent only slightly, so that in deep water the long length of protuding pipe had to be provided with some sort of support to keep it from bending permanently from its own weight. At the same time lateral supports had to be provided to assure proper placing despite water currents and windstorms.

The process used for the continuous laying of pipe from a barge, which was so fully equipped as to become in effect a mobile industrial engineering plant, was worked out by Standard of California engineers in collaboration with the constructor. The vessel, 180 ft. long and 40 ft. wide, had a narrow gage railway down its center, an overhead monorail crane, electric light plant, running water, compressed air, welding machines, asphalt kettle, a large portable crane, powerful winches to handle the cables, a cook house and mess hall. This permitted the conduct of continuous operation on the pipe laying proper while the essential shuttling between shore and barge was carried on by smaller craft. Lengths of pipe, ferried to the barge, were picked up by crane and placed on cars on the railway. Here they were welded together and the welded sections covered with Somastic. The barge was moved ahead as the work progressed by pulling on cables attached to piles. Pipe was fed from the stern over rubber-coated rollers, to maintain the protective coating in the best possible condition. In deep waters, a smaller barge followed, supporting the extending pipe on additional rubber rollers, suspended from outriggers on either side.

Progress was temporarily delayed on a number of occasions by the violence of windstorms and heaving water. The dragging of a side anchor at one time was responsible for twisting a section of pipe into the semblance of a pretzel; however, a diver with a hydrogen torch, operating under 35 ft. of water, cut out the damaged section and the schedule of construction was resumed. The personnel stood up well in the face of a very rigorous experience. Nightshifts were carried on under floodlights supplied by a diesel-operated generator, and the project was completed and in operation within one day of the engineers' estimate.

★ ★ ★

Line being laid in sea.



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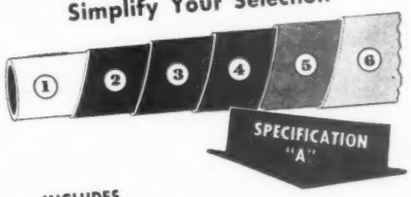

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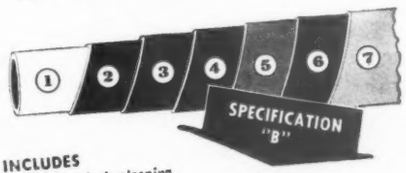
(5) One spiral wrapping of desired wrapping material.
(6) One spiral wrapping of heavy kraft paper.

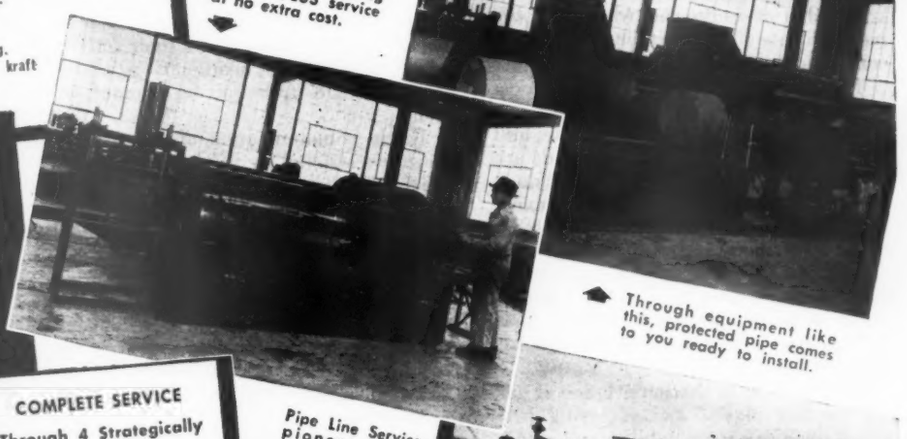


INCLUDES
(1) Mechanical cleaning.
*(2) Mechanical priming with desired primer.
(3) Hot application of desired coating.
(4) Hot application of desired coating.
(5) One spiral wrapping of desired wrapping material.
(6) Hot application of desired coating.
(7) One spiral wrapping of heavy kraft paper.

Here is a complete service that takes all the headaches out of pipe protection. You simply select either Specification A or Specification B together with the coating material desired. From there on, Pipe Line Service Corporation assumes full responsibility—secures the materials for you, furnishes the labor and takes care of every step right through to the finished job. No divided responsibility; no chance for slip-ups; satisfaction is guaranteed.

In every way, it will pay you to use this complete PLS service. It means only one order to write . . . one source of supply for your pipe protection requirements. Write for details.

All pipe is cleaned mechanically before coating and wrapping . . . a PLUS service at no extra cost.



Through equipment like this, protected pipe comes to you ready to install.

PROTECTIVE COATING MATERIALS Available on Above Specifications

Asphalts
Barrett Millwrap Enamel
Barrett Pipe Line Enamel
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*No-Ox-Id
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* Primer not required with No-Ox-Id coatings.

COMPLETE SERVICE
Through 4 Strategically Located Plants

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  - At the Mill
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Pipe Line Service pioneered the mechanical application of pipe protection over the ditch. The new Traveliner is the finest equipment available for this purpose.

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Pioneers in Steel Pipe Protection
General Office and Plant—FRANKLIN PARK, ILL.
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P 615.36

RADIO FOR THE GAS INDUSTRY

By **WARREN T. BULLA,** *Superintendent, Communications and Dispatching*

Natural Gas Pipeline Company of America

THE use of radio as a tool provides a means of communication available to the gas utility.

Operating headquarters of a gas company may intercommunicate directly with mobile radiotelephone stations installed in automobiles and trucks, and if the gas system is extensive, a system can be obtained to provide service from point to point.

EXCLUSIVE

Limited use of radio by utilities dates back to 1930, however, the greatest advance has been since 1936.

The limitation in the use of radio has been due largely to the limited number of frequencies available in the spectrum and to the development of the art.

Recently industry and the Radio Manufacturers Association operating as the Radio Technical Planning Board have been assisting the Federal Communications Commission in working out a plan for the greatest possible use of radio. Cooperating in this work are representatives of the gas industry, who have some knowledge of radio and who know the requirements for communication by gas companies.

The job of the Federal Communications Commission and those working with them requires a great deal of time, and although some new frequency bands are being made available, assignments must necessarily be slow, in order that existing services may be regrouped in some cases, to provide for grouping of services where the moving of some present users is for their advantage. Also, all requirements must be coordinated into a final pattern that will meet requirements for many years.

The increase in the importance of gas service has placed an increasing premium upon service reliability and stimulated the further study of methods of improvement by both preventive and curative means. The problem is one of control, for although all companies maintain expert mobile crews to perform the manual labor connected with the maintenance and restoration of service, these crews were not previously called on to coordinate so closely the timing of operations, nor to maintain so close a contact with a central point when in the field. These requirements have caused the gas companies to look for relief on this problem and turning to mobile radio seems a promising solution.

Some gas companies, particularly long-haul systems, have been using radio for several years, operating stations on the MF (medium frequency band). These hook-ups give service from compressor station to compressor station and provide communication when normal communication facilities fail. Also, portable equipment has been found very useful on major pipe line repair jobs, both planned and of an emergency nature. Automotive equipment with receiving sets installed in cars and trucks could be directed to a great advantage although they were in transit. This equipment provides satisfactory communication for most all requirements; distances up to several hundred miles are obtained under favorable conditions.

The author served on the Radio Technical Planning Board as a representative of the American Gas Association. Members meet with the Federal Communications Commission in Washington, D. C.

Distribution companies are using radio, two-way between one or more fixed control stations and their fleet of service cars and trucks to direct their activity while away from headquarters, when matters come up requiring prompt action.

Radio communication at the present time is restricted by FCC regulations to corrective situations; however, radio has such broad preventive possibilities that Committee 4, Panel 13, Radio Technical Planning Board, Power Utilities Group, feels that such restriction has retarded its fullest development in the public interest and in order that the industry may proceed with that development the FCC has been petitioned for a relaxing of the rules governing stations in the utility radio service.

We feel quite hopeful of having the present rules modified to permit use of radio for gas company operations essential to the effective rendition of service regardless of whether an emergency exists or not. Such use would perform a definite preventive function and, properly controlled, would not require a great many channel allocations. Inasmuch as severe emergencies invariably involve several services, we believe that the joint use of channels by different services is productive of severe interference when communication is most vital. We believe that any frequency or group of frequencies allocated for use by gas utility stations should be restricted for use in one or more specified geographical areas on the basis of a plan that should be submitted prior to the time that new frequency allocations are made. For the same reason, any general vehicular service that might be established would not appear to provide the top priority service demanded by gas utility emergencies.

New developments in radio equipment and performance will be forthcoming from the radio manufacturers shortly. FM (frequency-modulation) equipment on frequencies in the 30-40 mc band is accomplishing some excellent performances and over rather long distances. Recent equipment tests on 152-162 mc band has demonstrated some excellent transmissions in congested areas. Selective calling devices will permit the headquarters station to call any one or a group of two-way, or receivers only installed in mobile units.

There is a definite need for an industrial type "Walkie-Talkie" portable two-way set, and it appears likely to be available later. This type equipment would be particularly helpful for communication on gas pipe lines to coordinate gate operation on shut-outs and to direct the movement of men and material in inaccessible locations.

No doubt other developments in the radio art will provide other applications of interest to power utilities.

Classification of radio frequencies by bands are as follows:

	Frequencies (in kilocycles)		Designation	Abbreviation
	10 to	30, inc.	Very low	VLF
Above	30 to	300, inc.	Low	LF
Above	300 to	3,000, inc.	Medium	MF
Above	3,000 to	30,000, inc.	High	HF
Above	30,000 to	300,000, inc.	Very high	VHF
Above	300,000 to	3,000,000, inc.	Ultra high	UHF
Above	3,000,000 to	30,000,000, inc.	Super high	SHF

It is anticipated that the following frequencies may be allocated for use by power utility stations:

6 channels in the 2000-3000 kc band, subject to modification as required by international agreement.

12 channels in the25-30 mc band.

7 channels in the 30-40 mc band.

6 channels in the 72-76 mc band.

6 channels in the 152-162 mc band.

Specific frequencies will be designated by FCC at a later date.

The final allocation of frequencies may affect individual assignments, however, in view of the comprehensive study being made by the Federal Communications Commission, we feel that it will be in the interest of radio communication for the industry if any gas company so affected will willingly cooperate in this matter. ★ ★ ★

a new lease on life with a new home for five over-age storage tanks!

One lived in So. Norwalk, Conn.—Two in Rochester, N.Y.—another in Lockport, N.Y.—and the Fifth in Warren, Pa.... all of ripe old age, with rivets creaking in their sockets. They had outlived their usefulness, or so it seemed, till their owners (a major oil company) found that five tanks were urgently required at Detroit, Michigan.

Hammond was called in to do the surgery, the tanks were cut down, moved to Detroit, and today these once neglected old age orphans are in active service ... and of course as good as new.

This is but one of the great many rehabilitation jobs Hammond has performed ... others are now being carried on ... remember, please, whether it be rehabilitation or new tanks, you can depend upon Hammond ... for nearly half a century, designers, fabricators and erectors of tanks, vessels, steel and alloy plate work.

HAMMOND designs, fabricates and erects tanks of all types for liquid and dry storage ... above or below ground ... high or low pressure ... cone roof ... HAMMOND SPHERE ... floating roof ... vapor-lift ... spheroid ... gas holder ... also stainless and stainless clad vessels of all types and designs for the petro-chemical industries.

HAMMOND
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Exterior view of Panhandle Eastern's Olpe, Kansas, compressor station.

COMPLETES $10,000,000 EXPANSION PROGRAM

By **FRANK H. LOVE,** *Managing Editor*

AN outstanding accomplishment in pipe line construction during 1945 was that of the Panhandle Eastern Pipe Line Company. This gas transmission organization, which operates 1,250 miles of line from the Texas Panhandle to the East, in a period of approximately seven months completed a program costing in excess of $10,000,000. Involved was the erection of one new compressor station and dehydration plant, the addition of compressor units to 8 existing stations, the laying of 31.4 miles of 24-in. loops in Indiana and Ohio, the replacement of compressor cylinders in 11 mainline stations, installation of 134 mainline gate valves, addition of generating equipment, enlargement of cooling tower capacity, and extension to station buildings, to mention the larger items of the project. Consummation of this program effected an increase in operating pressure of one of the parallel lines from 500 to 600 lb. and an increase in line throughput of 50,000,000 cu. ft. a day.

EXCLUSIVE

New compressor units installed totaled 32,800 hp.—33 units varying in size from 800 to 1300 hp.

Pressure-welding pipe joints on loops laid in Ohio and Indiana.

Construction work was begun April 1, 1945, and by the latter part of November all main units were operating, although not all facilities were completed by that date—something of a record considering the amount of work accomplished.

It should be emphasized, too, that despite the speed with which this work was done, it was never necessary to shut down the system and gas moved uninterruptedly to war industries.

Such an accomplishment would have been impossible without the most careful planning prior to the beginning of actual construction work. In this respect every department of the pipe line company cooperated to the fullest extent. Engineering work was planned well in advance of the beginning of construction. An invaluable factor was the efficiency of the purchasing department. At no time was work delayed due to a lack of materials.

After construction work actually began, batch mixing plants were established to provide the large quantities of concrete needed (20,000 cu. yd. were poured) in the shortest possible time and with a minimum of manual labor. Heavy mechanical equipment was utilized to speed evacuation work and facilitate erection of steel structures. Stations were provided with duplicate traveling cranes to aid in engine erection. Air wrenches and other power-driven tools were used extensively, and all piping was prefabricated.

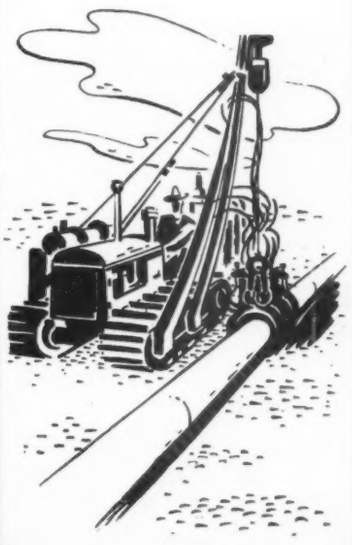
This new construction gives Panhandle Eastern a total of 170,600 hp. in 16 stations, believed to be the most compressor horsepower in a single gas transmission system. The compressor horsepower is distributed among the stations as follows: Sneed, Texas, six 1300-hp.

These Pressure Weld Clamps

Clamps and trained operators are available to contractors for all sizes of pipe welding jobs—anywhere. Write, wire or phone for quotations or information. May we send you literature describing Pressure Welding?

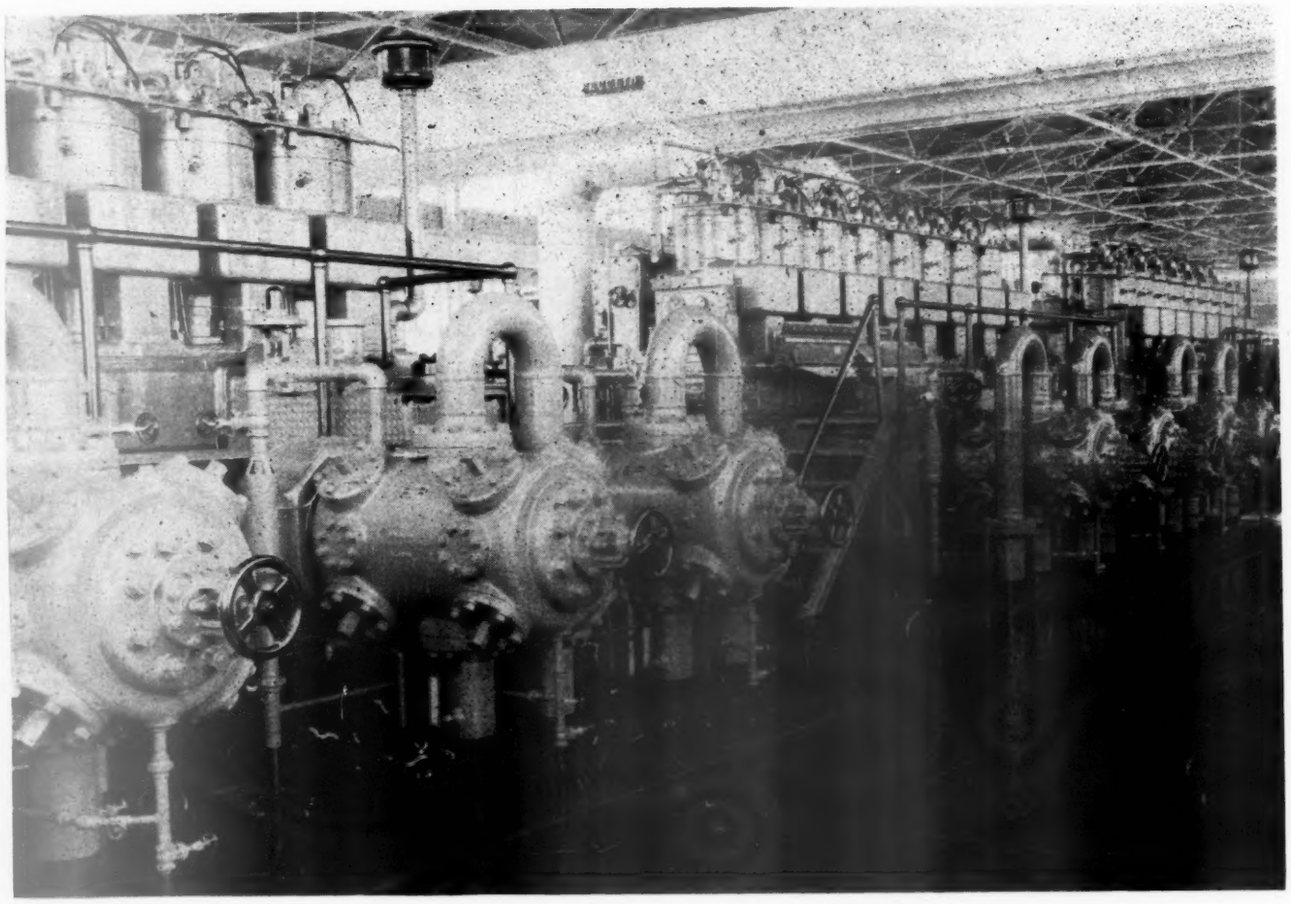
Will Weld Your Next Pipeline *Faster - Better - Cheaper*

Pressure Welding will materially increase the speed and substantially reduce the cost of welding your next pipeline job—whether it is laying 2 inch, 24 inch or any standard intermediate size of pipe. And, what is equally important, this semi-automatic process, making use of our patented Pressure Weld Clamps, a few of which are shown above, and other specialized equipment, produces welds of consistently higher quality without appreciably altering the physical properties of the pipe material. Large diameter pipe can be welded as fast as small pipe. A minimum of men and the small amount of self-contained, portable equipment required make Pressure Welding particularly ideal on rough or soft rights-of-way.



PRESSURE WELD COMPANY

421 NIELS ESPERSON BLDG. — HOUSTON 2 — TEXAS



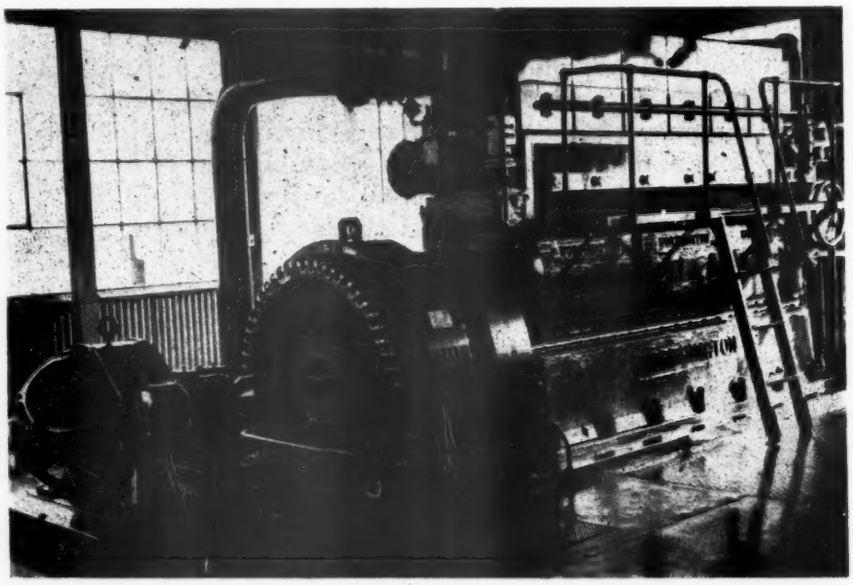
At Centralia, Missouri, 4 new 800-hp. angle type compressors were installed.

and four 800-hp. units, totaling 11,000 hp.; Hansford, Texas, eight 650-hp. and six 800-hp. units, totaling 10,000 hp.; Liberal, Kansas, eleven 1000-hp. units, totaling 11,000 hp.; Hugoton, Kansas, (new station), three 800 hp. units, totaling 2400 hp.; Greensburg, Kansas, twelve 1300-hp. units totaling 15,600 hp.; Haven, Kansas, eleven 1300-hp. units, totaling 14,300 hp.; Olpe, Kansas, six 1300-hp. and nine 800-hp. units, totaling 15,000 hp.; Louisburg, Kansas, fourteen 1000-hp. units, totaling 14,000 hp.; Houstonia, Missouri, ten 1300-hp. units, totaling 13,000 hp.; Centralia, Missouri, six 1300-hp. and six 800-hp. units, totaling 12,600 hp.; Pleasant Hill, Illinois, six 1300-hp. and six 800-hp. units, totaling 12,600 hp.; Glenarm, Illinois, ten 1000-hp. units, totaling 10,000 hp.; Tuscola, Illinois, four 1300-hp. and three 600-hp. units, totaling 7000 hp.; Montezuma, Indiana, seven 1300-hp. units, totaling 9100 hp.; Zionsville, Indiana, five 1300-hp. units, totaling 6500 hp.; and Edgerton, Indiana, five 1300-hp. units, totaling 6500 hp.

This constitutes 158 main units. In addition there are 56 auxiliary generating units that range in size from 180 to 400 hp. and have a total rated power of 12,979 hp.

● **New construction.** Of the main compressor units enumerated, 33 were installed in the 1945 construction program. Of the latter, some are of the angle and others of the horizontal type. At the new Hugoton station the three 800-hp. units are of the angle type. Four 1300-hp. horizontal units were installed at Greensburg, three 1300-hp. horizontal units at Haven, five 800-hp. angles at Olpe, five 1000-hp. angles at Louisburg, three 1300-hp. horizontals at Houstonia, four 800-hp. angles at Centralia, four 800-hp. angles at Pleasant Hill, and two 1000-hp. horizontals at Glenarm.

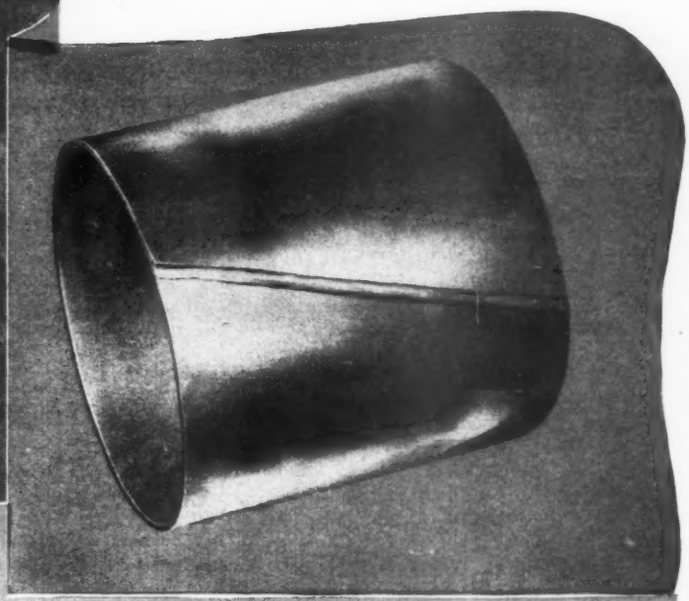
As an important part of the construction program eighty 500-lb. compressor cylinders were removed from 11 stations (Liberal to Montezuma, inclusive) and replaced with high pressure steel cylinders for operation at the increased line pressure. It was also necessary, for the same reason, to replace 134 mainline cast-iron gate valves with steel valves. These replacements were all made while maintaining service.



New units were added at a number of stations to increase electrical generating capacity. The unit is at Olpe, Kan.

Linde's UNIONMELT WELDING PROCESS
Speeds Joining of Metal

4½-in. steel slabs for diesel switcher underframes are welded in two passes.



14-gage sheet is spirally welded into pipe at a rate of 110 in. per minute.

18-GAGE SHEET can be welded at 240 in. or more per minute.

ONE-PASS WELDS even 3 in. thick can be made.

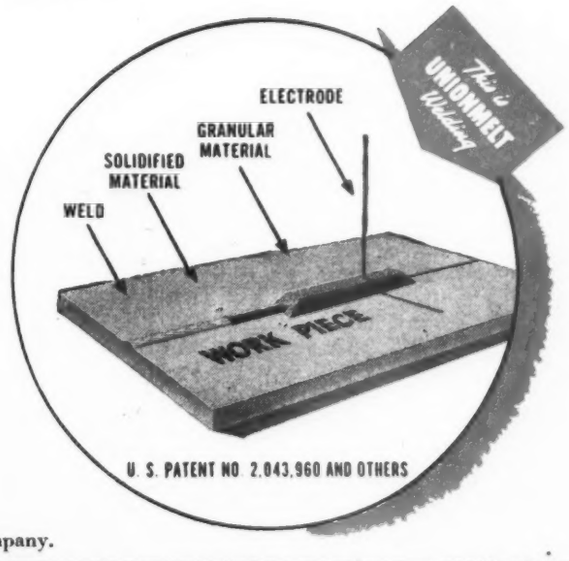
WELDING CURRENTS up to 4,000 amperes or more, a.c. or d.c. can be used.

BUTT, TEE AND LAP FILLETS, plug and molded welds can be made.

MINIMIZED DISTORTION is a result of high speed, narrow weld zone, and concentrated heat.

NO METAL LOSS from spatter or vaporization is encountered.

Anyone who wisnes to use this patented invention may do so under Linde's standard license agreement. Send for a copy of the new UNIONMELT book, Form 6077.



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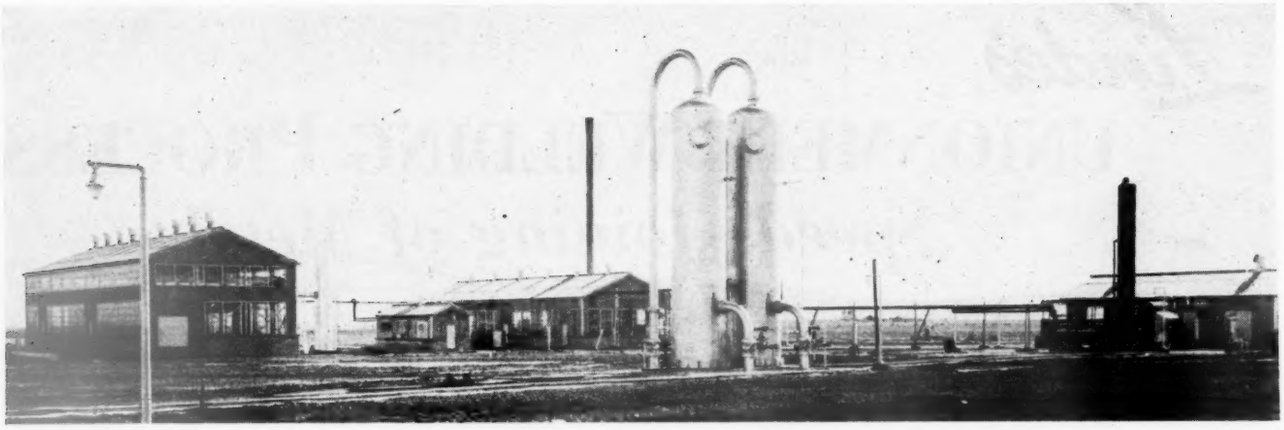


General view of the new compressor station and dehydration plant constructed in the Hugoton gas field.

At the Hugoton station, in addition to the gas compressor equipment and auxiliaries, a diethylene glycol dehydration plant was constructed, the absorption towers of which are 6½ ft. in diam. by 32 ft. high.

● **New type jacket water cooling unit.** Although previously used in other branches of the oil and gas industry, two Fin-Fan air-cooled forced-draft exchanger units for cooling engine jacket water were installed for the first time on a gas transmission system, one at Hugoton and one at Louisburg. This exchanger is a package type unit that combines the heat transfer surface with the air circulation equipment in proper mechanical and structural relationship to each other. Basically the unit consists of one or more helically finned K-Fin sections, fans having variable pitch blades, motors to drive the fans, supporting structure for the fin sections, and a cooling air plenum chamber.

At Hugoton the unit consists of two sections with two fans for each section. At Louisburg there are three sections with two fans for each section. The fans are driven by two-speed motors, thus providing flexibility and a saving in horsepower during cold weather.

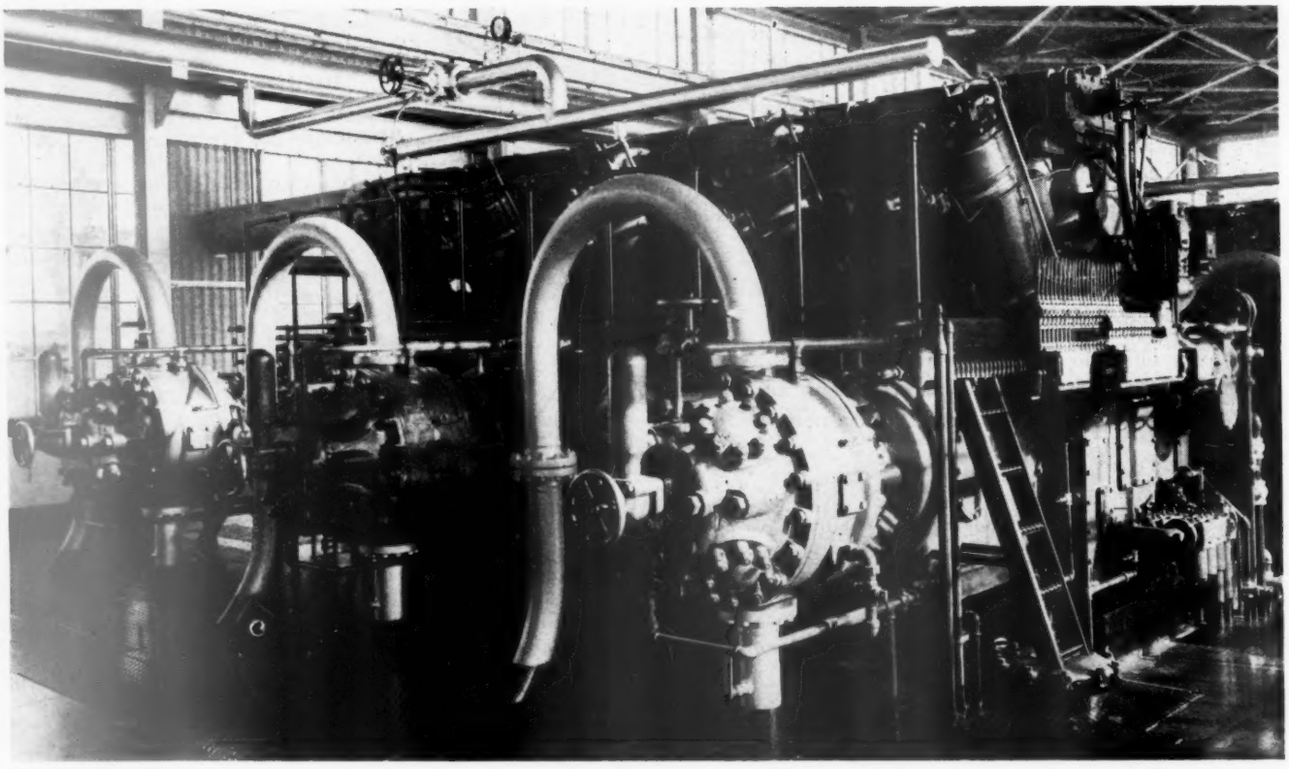
The fin sections are placed on top of the structure with the fans beneath. Fans, motors, and gears are mounted separate from and beneath the structure, which obviates the possibility of structure vibration. The forced draft feature, proper proportioning of openings on all four sides of the base for entrance of air, and proper depth of the plenum chamber to cause the air to spread evenly over the fin sections are some of the design features that effect maximum efficiency with a minimum volume of air.

The units at Hugoton and Louisburg receive the hot jacket water at a temperature of about 160°F. and discharge it at approximately 140°F.

● **Loop construction.** Two 24-in. loops totaling 31.4 miles in length were laid in Indiana and Ohio. The Indiana loop, between the Zionsville and the Indiana-Ohio boundary line, is 11.8 miles in length. The Ohio loop, 19.6 miles in length, is on the discharge side of the Edgerton station. In making these loops it was necessary to cross the Maumee River and to install two creek crossings.

Pressure welding was used throughout to connect the pipe joints. Certain improvements to this method, which was introduced to the pipe line industry several years ago, were used for the first time on this job. Welding clamps designed for more automatic operation than formerly resulted in speedier and more accurate alignment of pipe ends. The electric-switch equipment that releases automatically hydraulic pressure from the endo cylinders has been im-

New compressor installations at Louisburg consist of five 1000-hp. angle units of the type shown.



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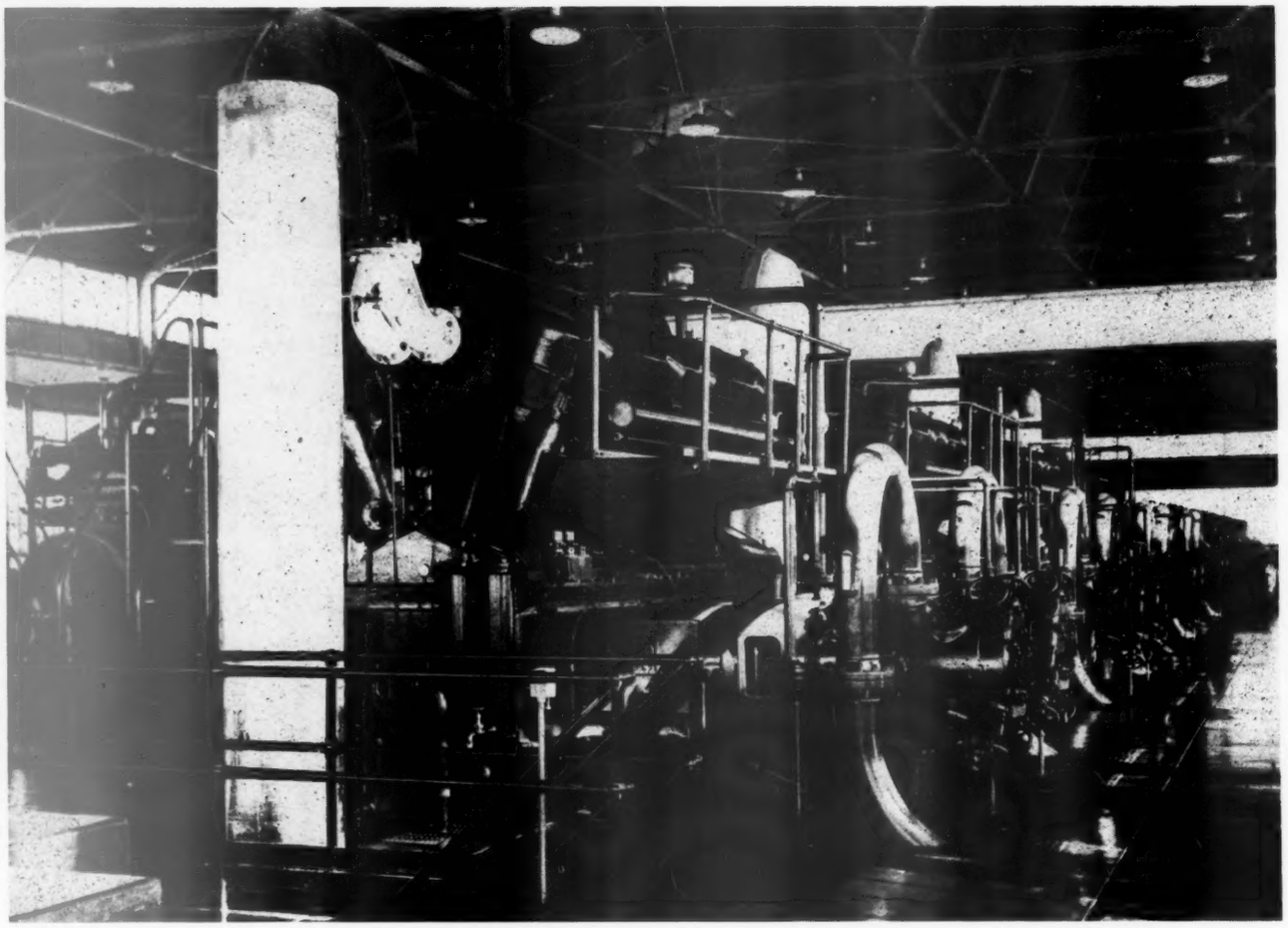
Pipe Cleaning, Coating and wrapping to any coating and wrapping specification

Complete Reconditioning Service for Old Pipe

MAYES BROS., INC.

HOUSTON, TEXAS



Interior of Olpe station—5 new 800-hp. angle compressors were installed.

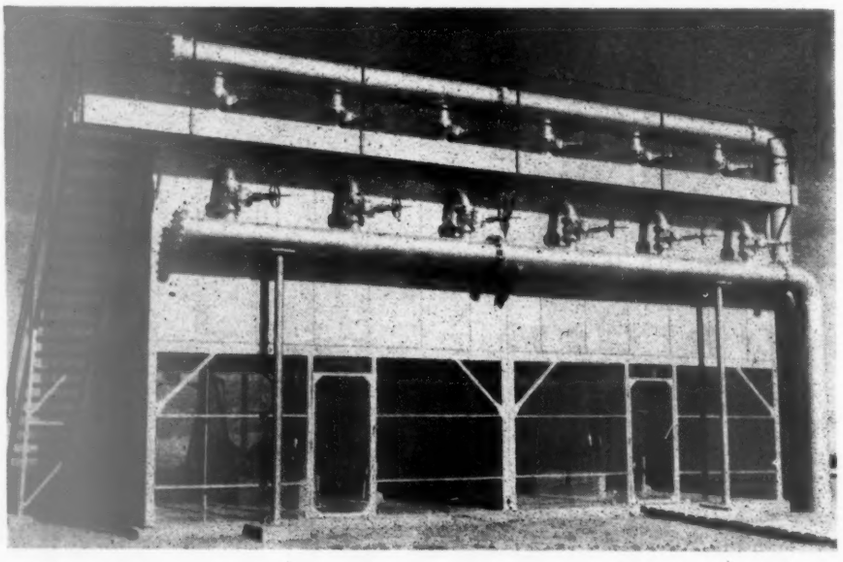
proved to control within narrower limits the upset produced during welding, resulting in uniform welds.

Inasmuch as proper adjustment of the flame is an exceedingly important factor in the pressure-welding process, a service engineer was provided at the beginning of the work by the company leasing the equipment. His job was to give operators initial instructions in accurate adjustment of the flame, enabling them to carry on the rest of the work without his assistance.

Equipment used to clean and prime the pipe also was of an improved type. This unit employs the buffer principle and essentially consists of a circular frame equipped with cylindrical brushes that revolve clockwise around the pipe while the individual brushes revolve counterclockwise.

The 24-in pipe used in the loops has a wall thickness of 9/32 in. An enamel coating was applied to the pipe over the entire 31.4 miles of loops by a traveling-type machine, and a part of the line was wrapped spirally with asbestos felt.

Jacket water cooling unit used for the first time on a gas pipe line system.



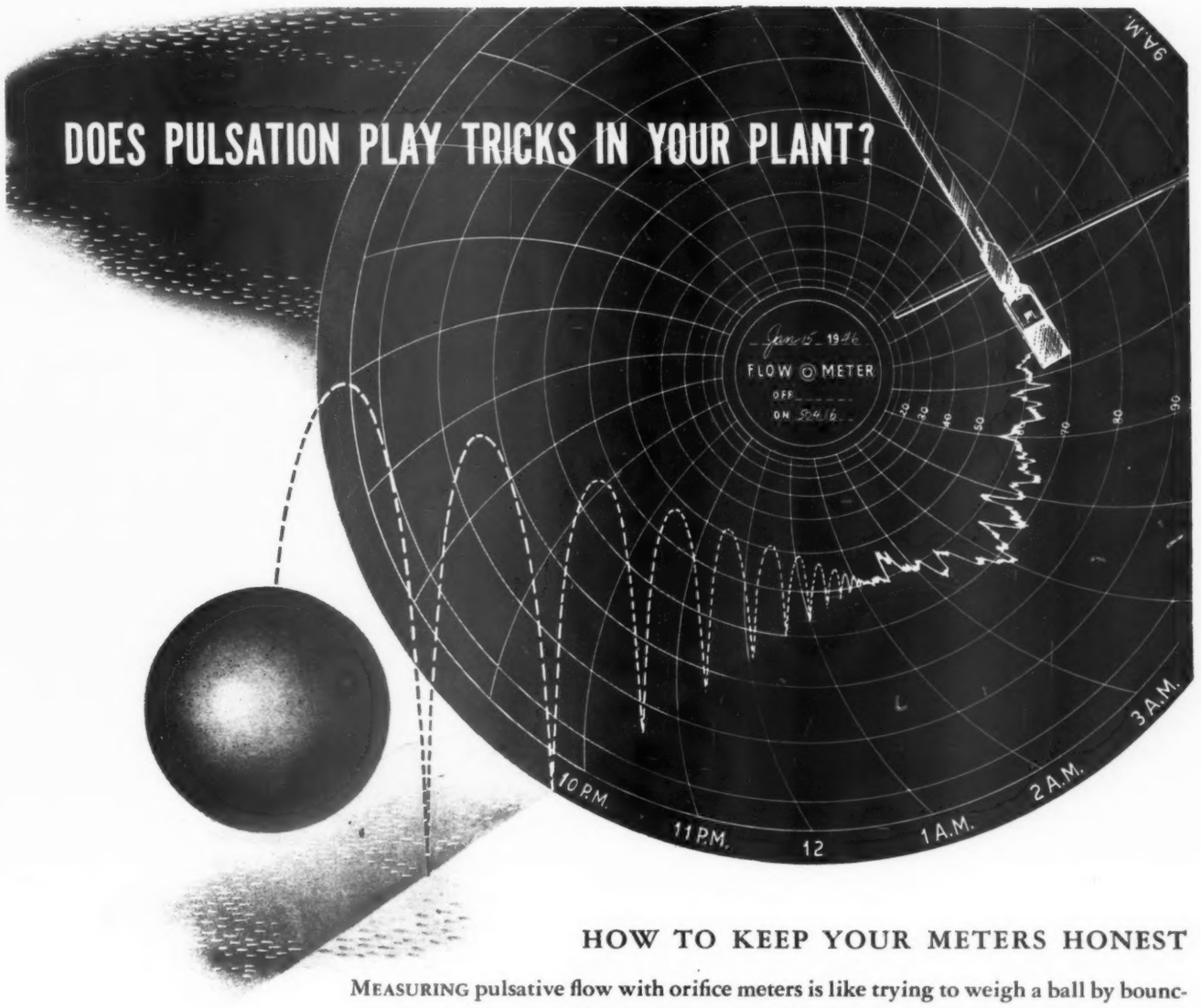
● **Two-way radiotelephones installed.** All stations on the Panhandle Eastern system are equipped with telephone as a means of communication, however, as a part of the 1945 construction program two-way radiotelephones were added for use in case of emergency. Company cars are equipped with mobile two-way units that make it unnecessary for operating personnel in the field ever to be out of contact with their area headquarters.

● **Contractors.** Three general contractors participated in the construction program. The Flour Corporation, Ltd., Los Angeles, California, built the new compressor station and dehydration plant at Hugoton, installed the additions to the stations at Greensburg and Haven, and made improvements at Liberal and Hansford.

The J. F. Pritchard Company, Kansas City, Missouri, made the additions at Olpe, Louisburg, and Houstonia, and the changes at Tuscola.

Midwestern Constructors, Tulsa, Oklahoma, constructed the additions at Centralia, Pleasant Hill, and Glenarm, and made the changes at Montezuma. In addition, Midwestern laid the loop lines and installed the high pressure mainline gate valves. ★ ★ ★

DOES PULSATION PLAY TRICKS IN YOUR PLANT?



HOW TO KEEP YOUR METERS HONEST

MEASURING pulsative flow with orifice meters is like trying to weigh a ball by bouncing it on the scales. Downward-upward thrusts give inaccurate readings... they happen so fast the measuring instrument can't keep up with them. To keep your orifice meters honest, pulsative flow must be converted into a steady stream. The FLUOR Pulsation Dampener is the practical answer to this problem.

For example—a large Eastern Gas Company pumps gas into underground storage during the summer and withdraws it during the winter when consumer load is heaviest. As storage reservoir pressure drops, it becomes necessary to compress the gas to maintain pressure in the mains. Pulsations set up in the gas stream by the compressors threw the meters off by such substantial amounts that the Company was unable to determine how much gas was being pulled out of the reservoir. FLUOR Pulsation Dampeners installed in the suction lines between the meters and compressors eliminated this condition and made accurate measurement possible.

The FLUOR Pulsation Dampener changes pulsative flow into smooth, steady flow... with beneficial effect on frictional losses, horsepower savings and rate of flow. If vibration plays *tricks* in *your* plant, it may be due to pulsations in air, gas or vapor lines. In that case, the FLUOR Pulsation Dampener is your answer.

fc SINCE 1890

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PIPE LINE GAUGING, SAMPLING, AND TESTING

By **JOHN A. SLEETH,** *Chief Gauger,* Union Oil Company

THE routine function of the pipe line gauger is to obtain such accurate measurements as are required to determine the exact quantity of gross oil shipped into the pipe line from tanks under his jurisdiction, and to make such tests as are required to determine in each instance the net quantity and value. The word "routine" is used advisedly here, for the gauger must also at times receive oils as well as ship it, and countless other jobs are numbered in his daily stint. Referring specifically to the shipping operations, however, the various data are acquired by precise, carefully defined methods, mostly empirical and hence demanding the closest adherence to operational detail. Stipulation is usually made in contractual agreements regarding the particular methods to be used, but in general, the gauging system involves the following separate and distinct steps:

EXCLUSIVE

1. Measurement of the gross volume of fluid in the tank.
2. Determination of gross fluid temperature.
3. Sampling that portion of the oil that is to be shipped.
4. Supervision of shipment.
5. Determination of gross volume and temperature of fluid remaining after shipment.
6. Testing of sample for water and sediment and API gravity.

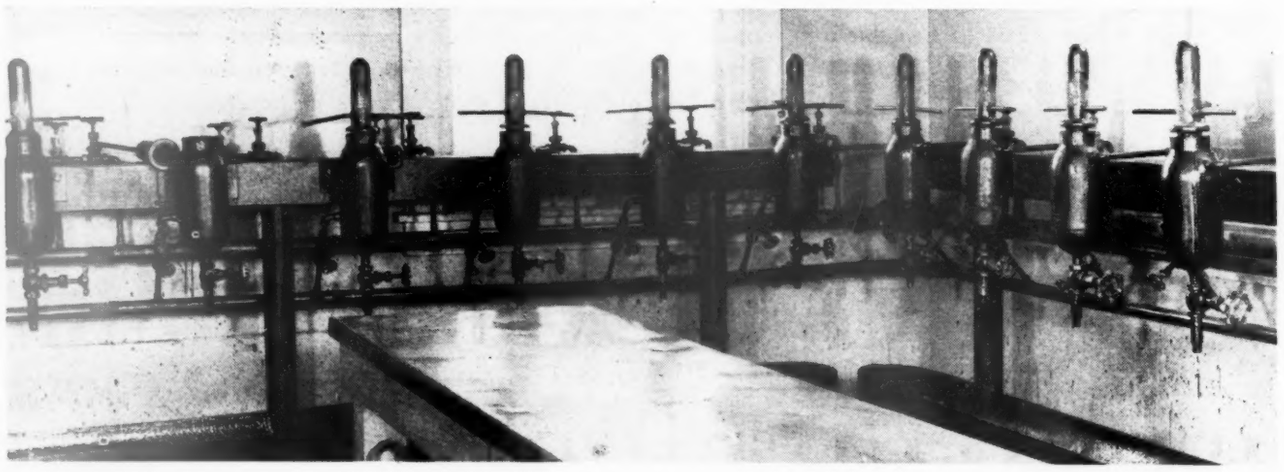
Although the petroleum industry over many years has taken steps to standardize and stabilize methods of measurement and test, it still becomes necessary occasionally to modify standard procedures to satisfy unusual conditions. We have learned that petroleums, differing to begin with in chemical constitution, and then in addition subjected to a wide variety of lifting methods and contingent influences, are likely to be greatly varied in physical character when they reach the surface. In the great majority of instances, the oils as produced are amenable to established treatments, but once in a while there occurs a condition that requires special handling.

Discussing, first, the determination of volume shipped, this is contrived by gauging with the customary steel tape and plumb bob the quantity of gross oil in the tank at the beginning of the run, and the quantity remaining when the run has been completed. These two quantities, corrected to 60°F., are subtracted to give the gross volume shipped. There would seem to be little chance for error in such a simple operation, and it is true that in this department circumstances requiring modification of method are rare, but they do crop up. An example that may be cited is one in which a wet and very heavy oil produced on a small lease was heated to remove the water, and in the process was whipped into a very frothy condition. For reasons that we need not mention here this oil had to be moved as it was. Samples were taken at once to the laboratory to determine the shrinkage when the occluded gas was removed, and a factor was thus established for correcting the gauge to a completely liquid state.

To obtain accurate results, it may be necessary also to take a number of gauges on a tank that has settled on one side, and there are other contingencies that can and do develop to render standard procedure momentarily inadequate. It should be emphasized, however, that the construction of oil tanks, and the gathering of oil, is the business of experts who know how to take care of their respective responsibilities in a manner that will obviate subsequent difficulties. The need for such departures as that described is, therefore, very uncommon. It is also to be remembered that representatives of both the buyer and the seller are involved in the gauging of oil, so that all extraordinary handling is usually the result of further contractual agreement or at least tacit understanding.

The method of sampling employed depends a great deal on the type and character of the oil being shipped. In many instances oil that is ready for the pipe line gauger is dry and uniform in quality from top to bottom, so that the standard method of taking equal quantities from a series of cocks in the side of the tank is very satisfactory. In others, the bottle thief seems to give accurate results, and when neither of these appears to provide the answer, resort may be made to the core barrel sampler, which is the most accurate of the three. Because of its simplicity and the fact that most pipe line oil is sufficiently uniform to permit its use, the multiple cock sampling method is by far the most popular. The range of sampling devices and methods approved by ASTM and API seem to give a sufficiently flexible coverage to take care of all the conditions normally encountered in making pipe line shipments, so that the method to apply in each particular instance can as a rule be agreed upon without much difficulty.

Pressure bomb assembly for determining dry gravity of low gravity viscous crudes.



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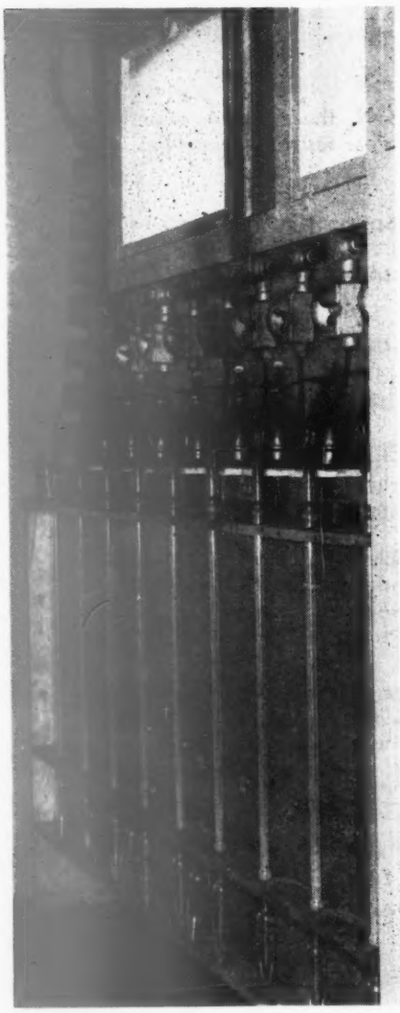
Bottle thieving and continuous coring, especially the latter, are somewhat messy to operate but for the conditions to which they apply are quite accurate.

Taking the temperature of the oil requires the exercise of care both in the placing of the instrument and in the reading. The number of thermometers used is determined by the capacity of the tank and/or the depth of the fluid. Here again if there is a need for deviation from the recognized method, it is brought to the attention of the proper authorities by the joint representatives of the buyer and seller and a satisfactory modification is agreed upon. The vast majority of pipe line shipments can be handled by prescribed standards and it is only when some abnormal happening precipitates it that a departure may be necessary.

The actual shipment of the oil is a matter that is outside the scope of this discussion, so we shall hereafter consider the testing methods in all their variations. For the determination of water and sediment, the centrifuge method is widely used. It is simple, once all the involved specifications have been cared for, and under certain conditions

Gauging laboratory showing constant temperature bath for hydrometric gravity tests. Centrifuge is on right. The laboratory technician is Margarete Barr.

Apparatus for determining water in crude oil by distillation. Sediment is determined in separate test.



can be very accurate, but it can also be highly inaccurate if it is simply applied in a general way, without regard to the widely divergent characteristics of crude oils. Ordinarily the method calls for the dilution of a measured sample of oil with enough benzol to bring the volume up to 100 ccs. This is then heated and centrifuged until all the water and sediment have been thrown out to the tip of the calibrated container, whence its amount and percentage can be quickly realized.

So far as California oils are concerned, results by this method are not at all reliable, and it seldom yields the true water content. Errors in the separation of the water and sediment are exaggerated by use of the multiplication factor. The substitution of a solvent consisting of 75 per cent light gasoline and 25 per cent carbon bisulphide makes the method much more applicable to California crudes. In recent years there has been an increasing use of solvents with demulsifying agents incorporated, and these have contributed substantially to the greater accuracy of the centrifuge method.

When the highest degree of accuracy is required, regardless of the nature of the crude, the method employed is distillation. The oil is contained in a metal retort, heated with an electric filament, and connected to a condenser, from which the water drops into a graduated receiver. This test can be made normally in one-third of the time it takes to run a centrifuge test, and since 100 cc. of sample are used, no multiplication of error is possible. The sediment content must of necessity be determined separately and added to the distillation result to yield the total water and sediment. One very small error that is inherent to this method is that the distilalate is pure water, whereas the water present in the oil is as a rule a highly concentrated brine. Determination of the salt content would thus also have to be made separately if it were required.

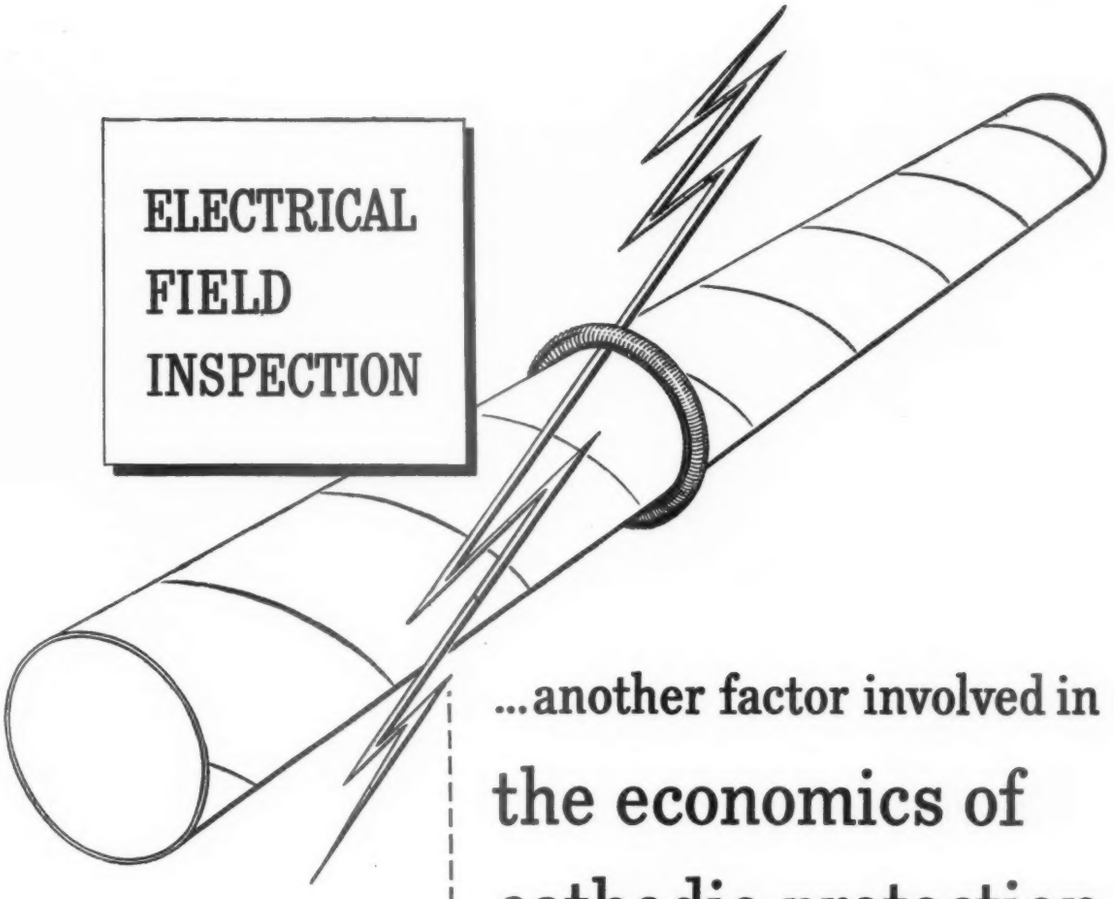
It is to be noted that the difference between the results of centrifuge tests and distillation tests for water and sediment in California crudes are by no means always in the same direction. Some comparisons from various districts are shown in the following tabulation:

Comparison of water content—centrifuge vs. distillation.

Source of crude	Water & Sed.	Water Dist.	Sed.	Total
San Joaquin Valley...	1.2%	7.1%	T	7.1%
Heavy, 12 to 14.....	2.8	5.4	T	5.4
Deg. API.....	3.0	2.4	..	2.4
Refining crude				
21 to 25 deg. API....	2.4	2.9	..	2.9
	1.6	1.3	..	1.3
Los Angeles Basin refining crude				
21 to 22 deg. API....	3.0	1.8	..	1.8
25 to 27 deg. API....	1.4	2.0	T	2.0
	0.4	0.8	..	0.8

These results tend to show that the establishment of standard procedure for the determination of water and sediment should be further supplemented by tests conducted locally to find which standard procedure is applicable in each case, and even when a method is decided upon, it is encumbent on the gauger to be on the alert for the sudden imposition of hitherto unencountered conditions that change the physical characteristics of the oil, and necessitate a change of method. It is fortunate that such changes manifest themselves usually in some recognizable form. After a little experience, the gauger can spot a change in color, which invariably indicates a change in the character of the emulsion present. It should also be remarked that the use of a solvent containing a demulsifying agent should be preceded by an investigation to select a demulsifying agent that is suitable. There are many different kinds of emulsifications and their resolution is a specialized performance that should be left to the specialists.

ELECTRICAL FIELD INSPECTION



...another factor involved in the economics of cathodic protection

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Coming now to the gravity test, the common method of immersing a hydrometer is familiar to everyone who has ever had an automobile battery tested at the service station, for the process is just a refinement of that well known technique. The crude being tested is maintained at a temperature that keeps it sufficiently fluid to float a hydrometer freely. Refining crude samples are cooled in the sample container to below 65°F. before being poured into the hydrometer jar for test. This is to prevent the evaporation of light material with a corresponding change in gravity. The oil is then maintained at a constant temperature while the gravity reading is being taken. By use of expansion coefficients, the gravity at the temperature recorded is corrected to the gravity at 60°F. It is interesting in this connection that hydrometer tests of extremely viscous crudes (Santa Maria 8.5° to 14° API) are being successfully performed by holding the oil under pressure at a temperature of 200°F.

It is perhaps not too well known and yet is an intriguing bit of history that the present API gravity scale is the result of a grand error. When one of the scientific organizations in the early days of the industry undertook to check up on the accuracy of the prevailing hydrometer, it was supposed to conform to the Baumé scale, but it did not. The Baumé scale has a modulus of 140/130 and it was found that the petroleum industry was using an instrument with a modulus of 141.5/131.5. Rather than attempt to call in all the hydrometers in service, a prodigious assignment, the instrument and modulus was adopted as an API standard and has continued to be the official standard of the American petroleum industry to the present time.

It is common practice for producers who operate in adjacent localities to ship their wet oils to a central treating plant for dehydration. In such cases it is obvious that when mixed at the plant, these oils lose their identity, and where there are a number of different types or gravities involved, proration becomes a highly complex mathematical problem. To obviate the need for any mathematical acrobatics, however, accounting is made on the basis of so-called "dry gravity" tests made prior to the time of shipment to the treating plant. Methods of determining dry gravity, that is, gravity with the water removed, are of two general types, and the one to be used in any specific instance is again determined by the character of the wet oil.

One method, used largely on low gravity, viscous crudes, is the pressure bomb method, in which the wet oil and demulsifying chemical are placed in a pressure bomb and the oil heated by steam for several hours. After pressure-temperature equilibrium is reached, the water settles out and is drained from the bomb. The dry oil is cooled under pressure in the bomb and is then transferred to a constant temperature bath, where the hydrometer reading is made in the conventional manner. This method is tedious and slow and is only to be applied where more expeditious processes are unavailing.

When a wet oil does not dehydrate readily by other means, its dry gravity can sometimes be determined by the "diluent and distillation" method. In this procedure, weighed quantities of sample and diluent, to which has been added an emulsifying agent, are thoroughly and intimately mixed. The hydrometer gravity of the mixture is then taken in the usual manner, and the whole is subjected to distillation. From the water content, the gravity of the diluent, and the gravity of the mixture, the original gravity of the wet oil can be calculated.

For light oils, the two popular means of determining dry gravity are the "chemical-centrifuge" and the "pressure filter" methods. In the chemical centrifuge method, 100 ml. of sample together with the requisite quantity of chemical demulsifier, are thoroughly mixed in a centrifuge tube, the tube is tightly stoppered and heated for a specified time in a water bath. The hot sample is then centrifuged until the water separated is equivalent to the water content as shown by the distillation test. The dry oil is cooled in the stoppered tube, then decanted, and tested for gravity in the normal way. The test is quickly and easily made and, when the proper chemical is used, consistently yields a dry oil for test. All hydrometers, thermometers, centrifuge tubes, and other measuring devices employed in any of the tests described here are checked for accuracy, and only apparatus subjected to this type of scrutiny is ever sent to the field for the use of the gauger.

In the pressure filter method, the wet oil is treated with a dehydrating chemical and forced through a filter, composed of supercel (diatomaceous earth) laid on canvas over a fine screen. The filtrate is caught in a separatory funnel or other receiver, and the dry oil is either separated by removing the water through the bottom vent of the funnel, or, if a graduate is used, by simple decantation. The gravity is then taken by hydrometer. This test, although slow compared with the centrifuge method, is reliable, and has been employed on many occasions to separate oil and water from emulsions so stable as to resist almost every other method.

The gauging system, although not completely applicable as it stands to all conditions met in the field and to all samples, is so flexible as to be capable of adaptation to almost any problem that might come to the notice of the gauger. In most purchasing and producing companies, the chief gauger is a technician whose interests are principally directed to the sample eccentricities and method adequacies that have been here described. In addition, he acts as a liaison between the pipe line department and research, so that problems too complex or too pretentious for local handling become research laboratory projects. So is the last word in accuracy and precision maintained! ★ ★ ★

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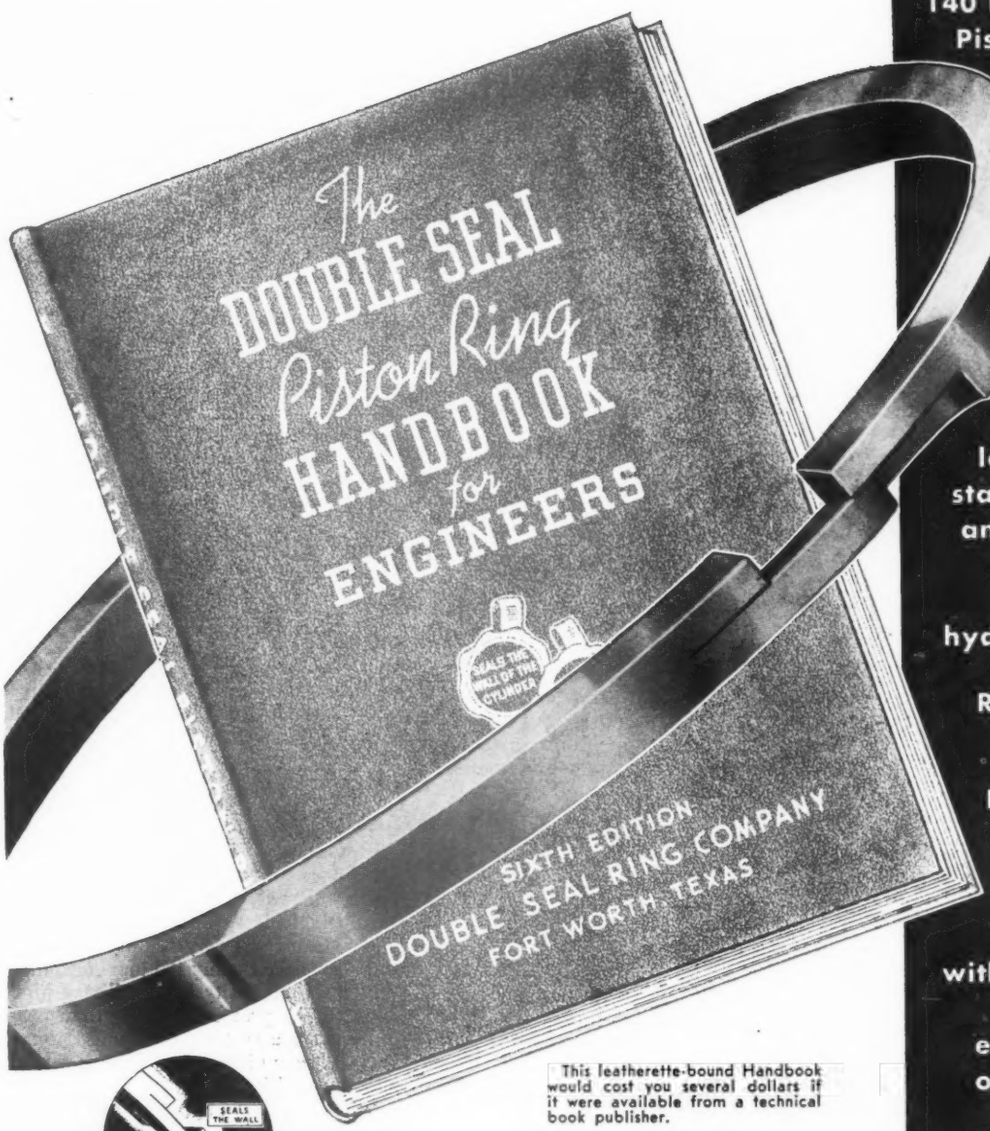

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MILITARY PIPE LINE SYSTEMS A WORLD WAR II DEVELOPMENT

By J. J. KING*
The Texas Company

EXCLUSIVE

ARTICLES appeared in various publications in the United States from time to time during World War II revealing the work of the Corps of Engineers of the U. S. Army in the construction and operation of pipe line systems for transporting gasoline for combat operations, and in the construction and operation of such facilities as ship-to-shore submarine pipe lines for unloading tankers and barges, tank farm terminals, and dispensing installations. Information has also been given on the responsibility of the Corps of Engineers in developing and providing for use overseas in combat areas petroleum products testing laboratories for checking captured petroleum products as well as petroleum products supplied from Allied sources. Little information has been offered, however, on the many problems that had to be faced and solved before bulk fuel handling materiél could be made available for overseas use and before trained military personnel to carry out this specialized work was ready for movement overseas.

These problems included the design of equipment such as pumping stations, lightweight pipe, special valve sections, manifolds for pumping stations, and hundreds of other items necessary for a complete military pipe line system. A military organization had to be set up and trained in all phases of the design, construction, and operation of bulk fuel handling facilities, and many items of special equipment for carrying out the mission overseas had to be designed and manufactured by the Army under difficult circumstances or procured from industry under equally adverse conditions. To train properly the military organization to carry out all the above functions in theaters of operations, training manuals were required. Such manuals had not even been written, but sufficient officer personnel from the oil industry was brought in to accomplish the task of preparing them. After the design of equipment had been completed and accepted by the Army, the problem on procurement had to be considered, and during the early part of the war the priorities for pipe line materiél were none too satisfactory.

*J. J. King was captain, Corps of Engineers, Petroleum Branch, War Plans Division, Office of the Chief of Engineers from December, 1942, to July, 1945. He is now with The Texas Company, Houston, Texas. Although this article was officially approved for publication by the War Department Bureau of Public Relations, the opinions given are those of the author and do not necessarily constitute an official expression of the War Department.

Although much has been written on military pipe lines, here are some little known facts by one closely connected with their planning.

It is believed that a resumé of some of the work carried out in the United States in connection with military pipe line systems will be of interest to those associated with the oil industry, for an overall picture of the part played by pipe lines and bulk fuel handling installations in supplying aviation and motor gasoline in theaters of operations will then have been provided.

Even as late as December 7, 1941, the U. S. Army had not perfected a military pipe line system adequate for handling gasoline and automotive diesel fuel for combat operations in quantities that would be required by the big-scale operations planned. As early as 1938 the War Department had under consideration the use of portable pipe lines for supplying petroleum products for combat operations, and in some of the maneuvers in the U. S. in 1940 serious consideration was given to the use of pipe lines for supplying fast moving armored forces in the field. During the early part of 1941, the Quartermaster Corps initiated a project to carry out experimental work on a short section of pipe line for bringing forward petroleum supplies to distribution points. Pipe 3 in. in diam. and in 20-ft. sections joined by means of a grooved-type coupling was used in the experimental lines. Gasoline engine driven centrifugal pumps served as pumping stations. The latter part of 1941 this pipe line system was utilized in maneuvers in North Carolina to transport motor gasoline from railroad tank cars to forward pumps for dispensing into cans and drums and, in some instances, directly into vehicles. The pipe line system was also used to move aviation gasoline from tank cars on sidings to airfields. The heavy requirements for motor gasoline during the maneuvers indicated the necessity for a military pipe line of much greater capacity than a 3-in. line and a system of extreme portability and complete reliability for actual combat conditions.

Two parallel 4-in. pipe lines in Italy that supplied the Fifth Army with gasoline.

Early in the war the Corps of Engineers was assigned the responsibility for the design, development, procurement, stockpiling, and shipment of all materiél to be used overseas by the Army in the handling of petroleum products in the bulk. This assignment of responsibility also included the carrying out of the mission of construction and operation of ship-to-shore submarine pipe lines, tank farm terminals, and all inland pipe lines. The Corps of Engineers also had the responsibility to develop, procure, and ship complete petroleum products testing laboratories to theaters of operations for use by the Army, although this responsibility was later transferred to Quartermaster Corps.

In the late months of 1941 the Corps of Engineers initiated experimental work on portable pipe lines for military operations, using light-weight pipe line sections 20 ft. long and equipped with end nipples machined to accommodate a groove-type coupling that used a rubber gasket to seal off pressure on the inside of the pipe. Pumps similar to those used in the petroleum industry were selected for pumping station installations. Special manifolds for the pumping stations and block and check valve sections

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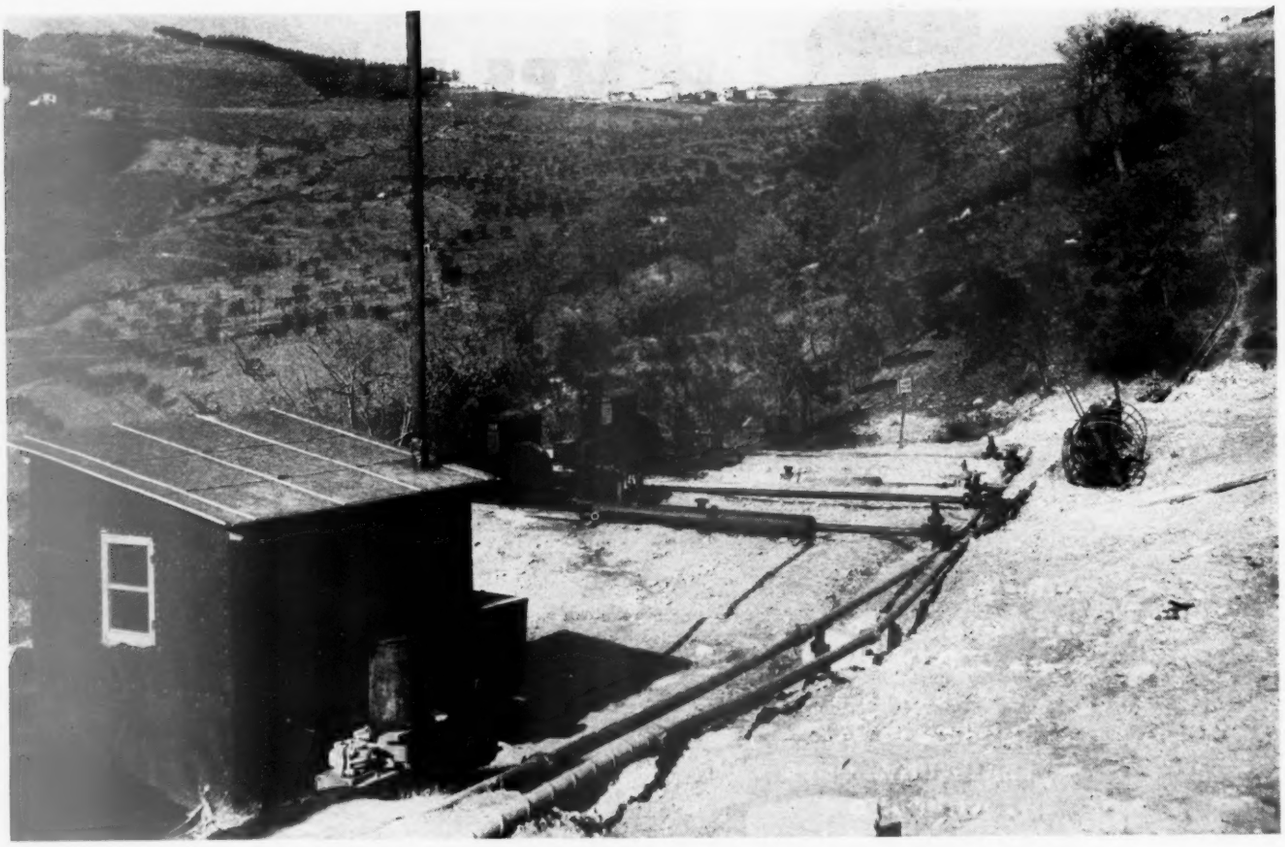

Typical pumping station installation for two parallel 4-in. pipe lines in Italy.

for use in the pipe line were also obtained. Certain automatic control devices developed by Sid Smith of Shell Oil Company for use on pumping stations and along the pipe line were incorporated by the Corps of Engineers in the pipe line system to be tried out. When sufficient material and equipment became available to provide about 20 miles of complete pipe line system, a site was selected in the Shenandoah Valley of Virginia and the experimental installation made. Care was exercised in the selection of the site to include mountainous terrain such as would probably be encountered in operations overseas. Experiments under many conditions of pressure and rate of flow were carried out over a period of several months and when the investigations were terminated it was concluded that the design was basically sound and with certain minor changes would be suitable for military operations overseas.

Contracts were placed immediately for hundreds of miles of 4-in. light-weight pipe line sections and sufficient pumping stations, couplings, valve sections, bolted steel storage tanks, and the hundreds of other items of material and equipment required for the installation of military pipe line systems. By the time the convoys for the North African invasion were ready to sail from the U. S. the early part of 1943, more than 1200 miles of complete 4-in. pipe line system with necessary tankage was aboard ships. By the time the North African campaign ended, most of the 1200 miles of pipe line had been installed for transporting aviation gasoline to airfields and moving motor gasoline to distribution points for use in trucks, tanks, and other motor vehicles.

While experimental work on the pipe line system was being rushed to completion in the Shenandoah Valley of Virginia, a training organization was set up at the Engineer Unit Training Center at Camp Claiborne, Louisiana, to train military personnel in the design, construction, and operation of military pipe line systems. Before training could be initiated, however, a suitable manual to cover all phases of pipe line design, construction, and operation was required. Inasmuch as the use of pipe lines for handling large quantities of petroleum products over great distances had never been carried out by the Army, applicable training manuals simply were not available. Officer personnel from the oil industry was called in to prepare a training manual that would cover adequately the type of pipe line system to be sent overseas, and the task of preparing the manual was carried out concurrently with development of the pipe line system to be shipped overseas. Through the incessant work of several officers, a suitable training manual in mimeograph form was made available in time to carry out a nominal amount of training for the Engineer Petroleum Distribution Companies, which accompanied the North African task force.

The providing of adequate petroleum products testing laboratories presented an almost insurmountable difficulty in view of the limited time available in which to assemble the apparatus and equipment. Trailers suitable for housing the portable equipment could not be procured from industry because such equipment had never been constructed in this country. The only alternative was to manufacture them by converting a certain type of Signal Corps trailer. This work was accomplished in the Heavy Shops at Camp Claiborne. When the time arrived to assemble the apparatus and equipment for the laboratories, a sufficient supply could not be obtained in the entire U. S. from manufacturers. Some of the officers assigned to laboratory duties had been with eastern colleges before offering their services to the Army, and were able to borrow many items of equipment on their personal promise that the loaned apparatus would be replaced or paid for. This is only one example of several that might be cited to illustrate the zeal with which many men in uniform from the oil industry worked under adverse conditions to make successful an undertaking new to the Army. These men had the firm conviction that combat operations would suffer if pipe lines capable of handling large quantities of petroleum products were not made available. Actual experience in all theaters of operation during the war proved their convictions were justified.

The table of equipment of the Engineer Petroleum Distribution Company provided for a large number of oil field

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type trucks, but these trucks in large numbers could not be obtained from industry on short notice. The only alternative was to produce them at Camp Claiborne, and the Heavy Shops were again called upon for assistance. A sufficient number of standard Army 2½-ton, 6 by 6 cargo trucks were obtained, along with heavy duty winches and other required materials, and oil field type trucks produced. Later, in order to conserve shipping space, a conversion kit was developed by the Office of the Chief of Engineers that allowed the Army 2½-ton truck to be converted to an oil field type truck overseas. This conversion kit was so designed that all work of converting could be accomplished with a minimum amount of shop tools.

The work of training personnel for Engineer Petroleum Distribution Companies and the manufacturing of equipment was so successful at Camp Claiborne that when the convoys sailed for the North African invasion, sufficient personnel and equipment was aboard ships to handle all pipe line construction and operation anticipated during the early phases of the campaign.

The value of pipe lines for handling petroleum products in combat operations was recognized early in North Africa and the training of personnel in the United States for this specialized work was speeded up as much as possible. It was also recognized that the capacity of the 4-in. pipe line would not be sufficient for many installations such as lines to groups of airfields and long pipe lines inland that would supply motor gasoline to vehicles along the highways and to distribution points close to active fronts. Design work was initiated early in 1943 on a 6-in. military pipe line system with a capacity of approximately two and one-half times that of a 4-in. line. Light-weight pipe line sections 6 in. in diam., similar in construction to the 4-in., were placed under procurement, along with 6-in. block and check valve sections. Reciprocating pumps were being used in the pumping stations for the 4-in. pipe line, but it was not feasible to use this type of pump for pumping stations on the 6-in. line due to the weight of the unit. In addition, there was a critical supply situation on industrial type gasoline engines of sufficient horsepower to drive a reciprocating pump of the required capacity. It must be remembered that extreme portability was desired in in the military pipe line system. Following considerable investigation of centrifugal pumps available from industry in large quantities, a high-speed, light-weight, 2-stage pump of suitable capacity and working pressure was selected. A contract was awarded for mounting the pump on rigid skids with a high speed gasoline engine that could be obtained in almost unlimited quantities. Pumping station manifolds were designed to permit installation of the pumps in pairs for operation in parallel or in series and were equipped with certain automatic shut-down controls. By the middle of 1943, 6-in. military pipe line was being shipped overseas, although in limited quantities. Of the total military pipe line system sent overseas during World War II, more than half was 6 in. In one area in the European Theater there were 3 paralleling 6-in. pipe lines extending hundreds of miles inland from port tank farm terminals.

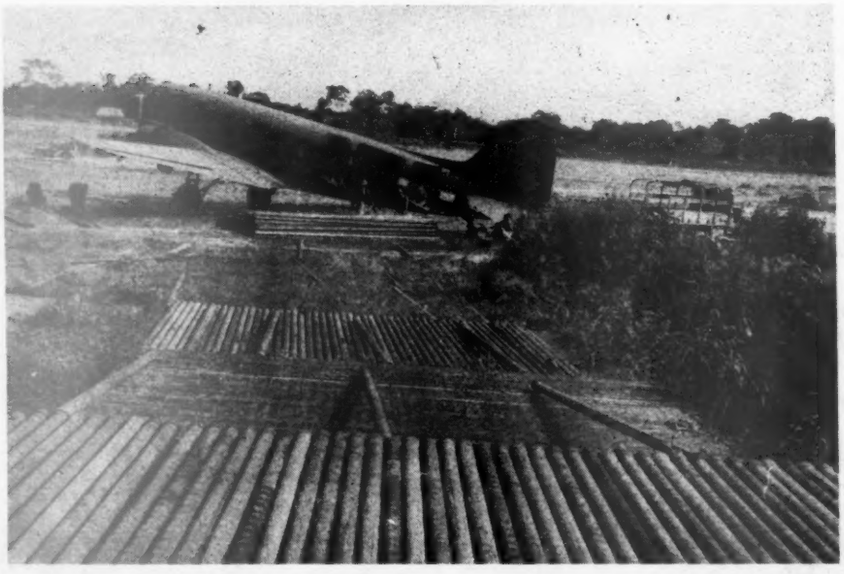
At the Quebec Conference in August, 1943, certain long pipe line systems were authorized for the China-Burma-India Theater. These pipe lines were intended primarily to supply combat forces in China, and because of the position occupied by the Japanese forces in Burma and China at that time, the routes of the lines crossed territory ranked among the world's most isolated terrain. These pipe lines were destined to be the longest ever attempted by the military or by industry and were to be installed under the most adverse weather conditions. Target dates selected were such that construction work necessarily had to be carried out in bad as well as favorable weather. One 750-mile section of 6-in. pipe line in India and Burma was constructed over a period of approximately 5 months and during the worst months of the monsoon season when the rainfall was so continuous that the men worked for one 45-day period without dry clothing. Other sections of pipe line were also installed during monsoon seasons, over extremely difficult terrain and in close proximity to actual combat operations. Passes of 9000-ft. elevation were encountered in some instances. Lead construction crews frequently had to mark time while combat troops cleared out Japanese die-hards only a few miles away.

The total mileage of pipe line authorized for the China-Burma-India Theater was so great that the Engineer Petroleum Distribution Companies in training in the United States at that time or available for movement overseas could have accomplished little more than the task of sorting and stockpiling the pipe line materiél as it would be unloaded from ships in the theater. Immediate activation of several additional E.P.D. Companies was directed and large supplies of training equipment shipped to Camp Claiborne. So huge was the undertaking of training the required military personnel that more than 300 miles of 4 and 6-in. pipe line system was required, and at the peak, training was carried out 24 hours each day through the use of a field electrification system. Continuous operation of two tank trucks was necessary to supply fuel gasoline to the pipe line pumping stations.

Even in the face of almost impossible deadline dates, the theater was supplied with the required trained personnel, although to accomplish this feat it was necessary to design and install aboard one of the troop transports a miniature pipe line system to allow several hundred enlisted men to acquire actual experience in the operation and maintenance of pumping stations and special control devices.

In order that complete bills of materials for the pipe lines for the China-Burma-India Theater might be made available to the ports of embarkation with least possible delay, preliminary design work on approximately 2000 miles of 4 and 6-in. pipe line was carried out by the Petroleum Branch of the Office of the Chief of Engineers in Washington, D. C. As the pipe lines were to be constructed over swampy areas as well as mountainous terrain, many special items of material and equipment in addition to standard military pipe line materiél were needed. Several rivers were to be crossed, some by suspension bridges, others by under-water pipe lines. One under-water river crossing was approximately 2 miles long, and a suspension bridge for a single 4-in. line was more than 900 ft. long for one installation. Included in the special material and equipment were tramways for

C-47 transport being loaded with 4-in. pipe line sections in India for movement over the "hump" to China.



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moving pipe line materiél across gorges, light-weight gasoline engine driven winches, light-weight arc-welding equipment for pipe line welding, cable for suspension bridges, fire fighting equipment for isolated installation and for extremely low temperature operation, extra heavy pipe for river crossings, and many other items. As some of the lines were to traverse disease laden areas, many special items of medical supplies and equipment were required. Every precaution possible was taken to guard against loss of personnel due to disease, insect bites, etc., for it was realized that the men would be on duty under all kinds of weather and working in water for days at a time with little relief.

Near the end of 1943 authority was obtained to set up a table of organization and equipment for 3 pipe line headquarters groups to be responsible in the China - Burma - India Theater for planning, supervising construction, and the operation of all pipe line systems to be installed in that theater. The theater was authorized the necessary grades and strength to constitute the headquarters groups, and personnel was selected in the United States to provide as many men as possible with previous pipe line or oil industry experience. A reasonable percentage of officers with this industry background was ultimately assembled in the United States. Before movement overseas, all the officer personnel for the headquarters groups was sent to Camp Claiborne to observe the training procedure and become familiar with the military pipe line system. Upon arriving in the theater, these headquarters groups assumed responsibility for all subsequent design work on pipe lines, tank farm terminals, ship-to-shore submarine pipe lines, and all other bulk fuel handling facilities.

In the China-Burma-India Theater it was considered desirable to construct some of the pipe line systems in accordance with industry practice in the United States, by utilizing standard weight pipe and high pressure pumping stations to permit the lines to operate at a pressure of 700 and 800 lb. per sq. in. Certain sections of these lines were welded whereas other sections utilized couplings such as were provided for the strictly military pipe line system. Heavy duty reciprocating pumping stations weighing complete more than 10,000 lb. were provided almost exclusively for the high pressure lines. In some cases the pumping station spacing on these lines was such as to allow the delivery of almost 20,000 bbl. a day under 100 per cent load factor.

The longest military pipe line constructed during World War II was in the China-Burma-India Theater. With the completion of the 4-in. pipe line to the airfields east of Kunming, China, gasoline was being transported through a continuous system of pipe line more than 2000 miles long.

Operations in the Pacific Theaters did not require long pipe lines, for most of the combat areas were islands of limited size; however, due to the high concentration of airfields, many tanker unloading installations and large tank farm terminals were required. Line capacities between port and beach head tank farm terminals were necessarily large to supply the heavy demands for aviation gasoline for the very long range bomber fields. In general, the light-weight military pipe line system was utilized in all Pacific Theaters and proved completely satisfactory. Many of the large tank farm terminals required manifolds of 8, 10, and 12-in. pipe, and in most cases this pipe was joined by welding, although groove type couplings were provided for some of the jobs.

During the early months of 1944 and shortly before D-Day in the European Theater of Operations, the requirements for military pipe line system, bolted steel storage tanks and trained personnel to carry out the construction and operation work in the theater, were greatly increased over previously stated amounts. In order to meet these demands it was necessary immediately to place under procurement several thousand miles of 6-in. light-weight pipe, couplings, and pumping stations. As the European Theater carried the highest priority for materiél and personnel, diversion of both Engineer Petroleum Distribution Companies and materiél scheduled for other theaters was made to meet the requirements of the theater. Through the speeding up of production of 6-in. pipe, couplings, and pumping stations and the diversion of materiél and personnel, ample bulk fuel handling facilities were provided for the European Theater of Operations. Although pipe lines in France and Germany were not so long as some in the China-Burma-India Theater, several thousand miles of military pipe line system was in operation when the war ended. At the peak of operations, more than 125,000 bbl. of gasoline and automotive diesel fuel per day were being handled by pipe lines in the European Theater.

Without pipe lines, the movement of gasoline and diesel fuel for the Army from port and beach head tank farm terminals to airfields and to the active fronts would have been accomplished by means of tank trucks or cargo trucks carrying the fuel in drums, 5-gal. cans, and other containers. To attempt to estimate the saving in personnel, trucks, container manufacturing facilities, and road repair equipment as a result of the use of military pipe line systems would be conjecture; however, it was recognized early in the war through the use of pipe lines for liquid fuels that this facility would be a necessity for heavy bomber operations and rapid movement of ground forces. This fact became more evident as the war progressed. The value of pipe lines for military operations can be illustrated by an example from one theater where a 6-in. pipe line that paralleled a 750-mile railroad was capable of handling as much gasoline as could the railroad had it been operated at maximum capacity and all its facilities devoted to hauling fuel in tank cars.

★ ★ ★

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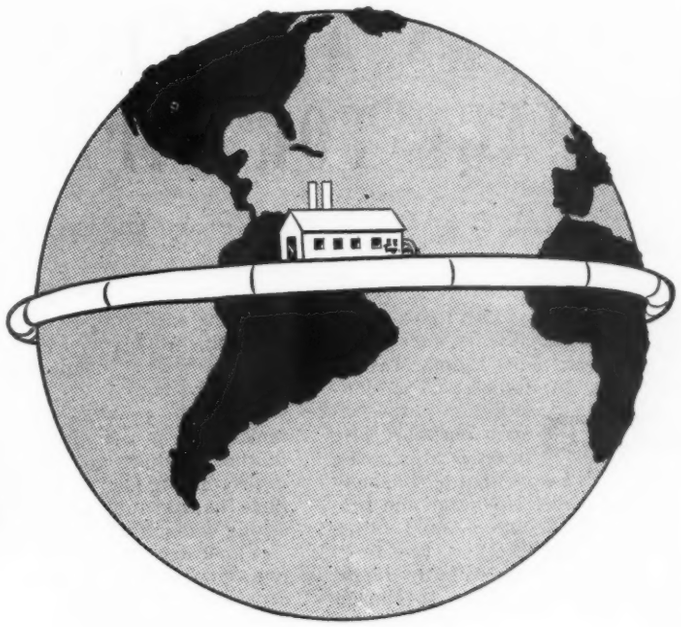

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FACTORS AFFECTING SELECTION OF STORAGE FOR PIPE LINE TERMINALS

By **D. E. LARSON,** *Development Engineer,* Chicago Bridge and Iron Company

LET US begin by saying that any oil storage tank is admittedly an evil but a very necessary one at that. Any oil man will agree. A storage tank is something he doesn't want but must have in order to carry on his business. It is somewhat like a safety deposit box. It affords storage and protection for something valuable to its owner but nothing more.

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The storage of any volatile liquid product costs money. This cost is made up of (1) the initial cost of tanks and fittings amortized in some specified period of time; (2) the interest on the investment in tankage; (3) the cost of tank maintenance, and (4) the cost of product lost by evaporation. The total storage cost made up of these four items may be quite low or very high, depending on how intelligently the storage problem is handled.

Fortunately, most of the petroleum products used in large quantities today can be stored at a cost of a few cents per barrel per year by selecting the type of tanks best suited to the conditions under which they will operate.

The surest way to reduce storage costs is to eliminate the storage. There is a definite trend in this direction. Pipeline men have long dreamed of the day when improved pumping equipment would eliminate the need for balancing tanks at pipe-line stations. Their dream is coming true because centrifugal pumps, which do not require balancing tanks, are slowly but surely replacing the old reciprocating pumps; but there is another side to the story on pipeline tankage. Year by year the number of different products handled through pipe lines has increased. As a result, more and more tanks have been added at all marketing points to handle the new products. The need for pipe-line storage tanks has not passed, it has merely changed in character.

The heavy drain on our petroleum reserves during the war placed great emphasis on the need for stronger conservation measures. Realizing this need, most oil companies are making a determined effort to reduce storage and handling losses wherever possible. Equipment manufacturers are assisting by improving their old products and bringing out new ones. A greater selection of equipment for storing and conserving volatile petroleum products is now available than ever before. It is all the more essential, therefore, to make a careful study of each proposed installation to determine what type of tankage will provide the most economical storage.

Let us suppose you are an engineer who has the problem of specifying the tankage to be used for storing various finished products at a pipe-line marketing station. A few years ago, you might have begun such an assignment by asking yourself whether any type of special tank or roof could be economically justified. Today, it is almost a foregone conclusion that functional tankage will provide the most economical storage and you will probably direct your efforts from the start toward determining which of several types of storage vessel is best adapted to your particular operating conditions.

First of all, you may wish to investigate the kind of installation shown diagrammatically in Fig. 1. It consists of tanks with fixed roofs having their vapor spaces connected by vapor lines to other tanks with roofs of the lifter or expansion type. At one time there was considerable discussion regarding whether the vapors from product "A" stored in one tank in a vapor saving system might contaminate product "B" stored in some other tank. This has been investigated and it now seems to be rather generally agreed that the amount of contamination caused by the intermixing of vapors

FIG. 1. Vapor-saving system employing new fixed roof tanks reinforced to withstand operating pressure of lifter roof. Suitable for installations where tanks average half full and filling balances emptying.

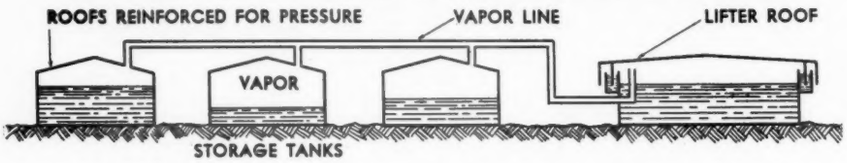

FIG. 2. Vapor-saving system utilizing Vaporsphere instead of lifter roof. Storage tank roofs need not be reinforced because Vaporsphere operates at very low pressure.

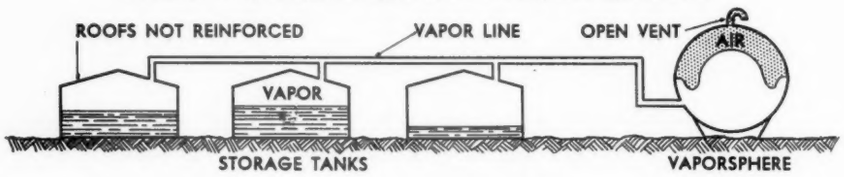

FIG. 3. Pressure storage system. Vaporsphere is optional and is used only if needed because of unbalanced filling and emptying. Excellent where tanks all filled and then emptied slowly.

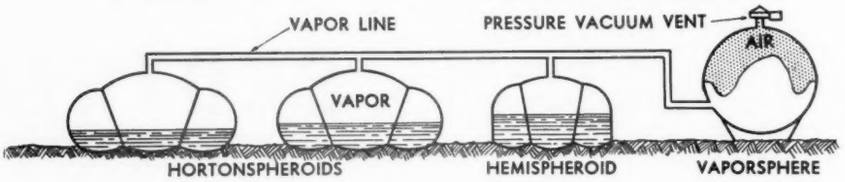

FIG. 4. Floating roofs provide most flexible and efficient installation for any group of working tanks. Floaters insure lowest storage cost for tanks filled and emptied more than five times per year.

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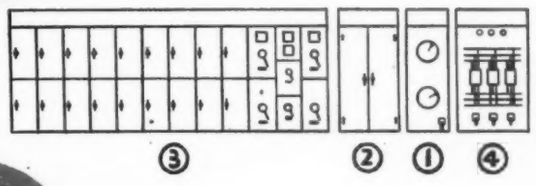
WHAT DOES AN Automatic Process-timing System CONSIST OF?



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This 8-page, illustrated publication contains an interesting explanation of G-E automatic process-timing control. Includes description of each component part and its function in the operation of the system.

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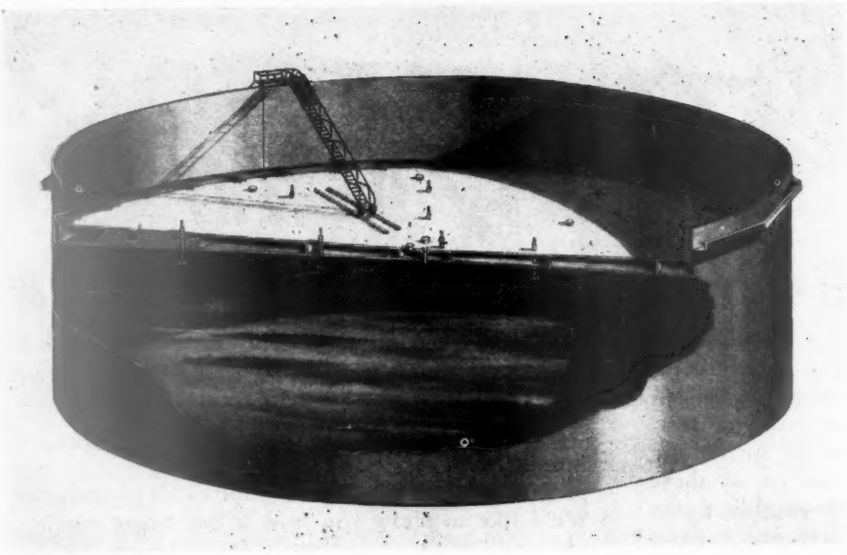


FIG. 5. Oil storage tank equipped with Horton floating roof.

from different tanks containing finished products is strictly negligible.

The lifter roofs in a vapor saving system should have sufficient capacity to retain the vapors that would otherwise be expelled from all the storage tanks as a result of daily temperature variations. It is also desirable to provide some additional capacity in the lifters to retain vapors displaced by unbalanced pumping. It is assumed, of course, that you anticipate a fairly good balance between the filling and emptying of various tanks; othewise, you would not consider this type of system to begin with. It is not suited to a terminal where all the tanks are filled at one time and then emptied completely before being refilled. Under such conditions, a prohibitive amount of lifter capacity would have to be provided in order to prevent all the breathing loss as the tanks approached the empty point.

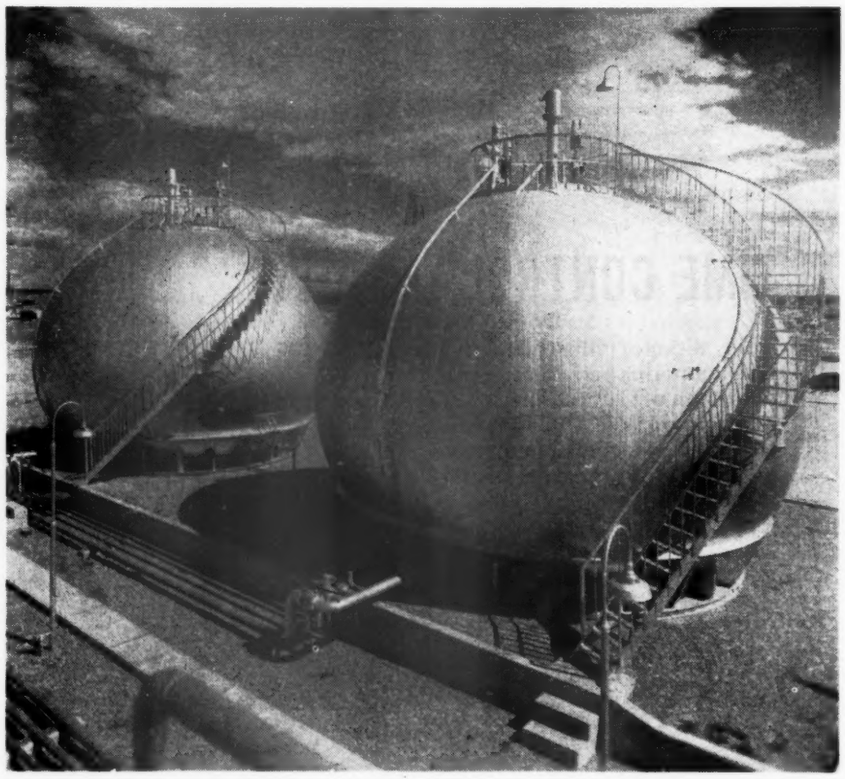
Lifter or expansion roofs of the liquid seal type operate at pressures ranging anywhere from 2½ in. of water to 7½ in. of water depending on the roof diameter and height of lift. This imposes a problem that requires careful consideration when a lifter roof tank is to be connected by vapor lines to one or more tanks with fixed roofs. Cone roofs of standard design are not capable of withstanding any appreciable amount of pressure. Consequently, it may be necessary to safeguard them either by reinforcing the top angles to enable them to resist the greater compressive stress caused by the increased pressure, or by placing weights on the roof plates to reduce the net uplift on the roofs. If weights are used, the strength of the roof columns must be checked to make certain that they are capable of supporting the weights in addition to the snow and vacuum loads for which the roof framing is designed. It is a simple matter to strengthen new tanks, but difficulties are sometimes encountered in cases where existing tanks are to be connected into a vapor saving system.

If existing tanks are to be incorporated into the vapor saving system you are considering, the problem of strengthening the roofs can be avoided by planning to use a separate gasholder capable of operating at a much lower pressure than a lifter roof. The Vaporsphere shown in Fig. 2 is a low pressure gasholder that is ideally suited to installations of this sort. It consists of a Hortonsphere of light construction within which is a hemispherical flexible membrane attached to the shell of the sphere at the equator. When the Vaporsphere contains no vapor, the membrane rests on the bottom half of the shell and the space above it contains air. As vapor enters through the inlet below the equator, the membrane rises causing air to be displaced through the vent at the top. When the sphere is full of vapor, all air has been displaced and the membrane is in contact with the upper half of the shell, which backs it up and prevents it from becoming stressed.

A Vaporsphere with an open vent at the top operates at a pressure of approximately ⅛ in. of water. It can be made to operate at any higher pressure that may be desired by using a pressure vacuum vent instead of an open vent on the air side of the membrane. This vent maintains a back pressure on the membrane that regulates the pressure throughout the system. It must, of course, have a lower pressure setting than the vents on the storage tanks connected to the Vaporsphere; otherwise, the tanks would vent before the Vaporsphere became filled.

Should you finally decide on either of the vapor saving systems shown in Fig. 1 and Fig. 2, another important part of your job will consist of specifying the fittings to be used on the storage tanks. This type of installation has one very serious weakness, which is that a single opening to the atmosphere at any point will destroy the efficiency of the entire system. The fittings you specify must be and must stay vapor-tight and must be so designed that gaging, sampling, and other necessary operations can be carried on without loss of vapor.

FIG. 6. Typical installation employing small Hortonspheroids for storage of liquefied petroleum gases.



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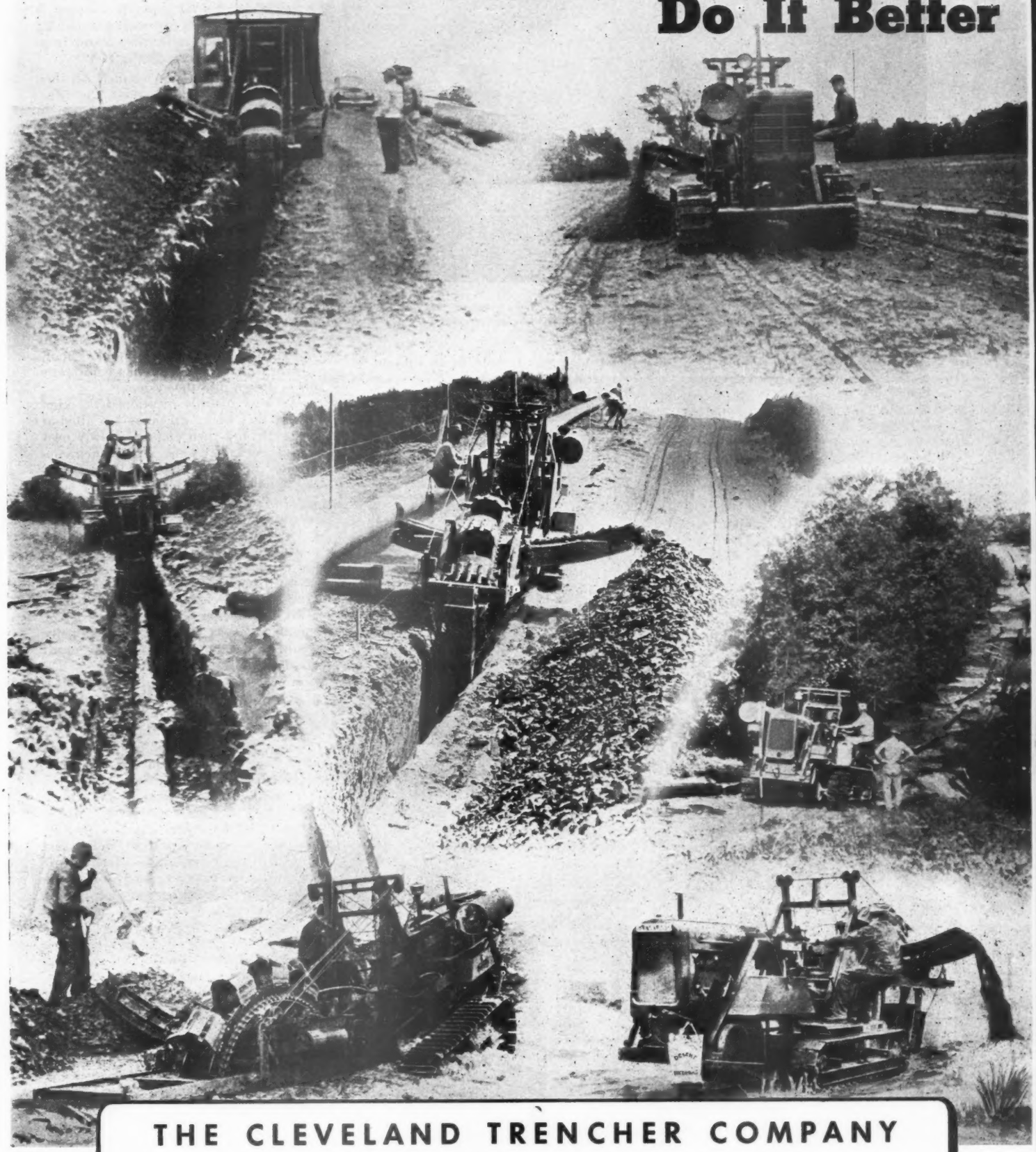

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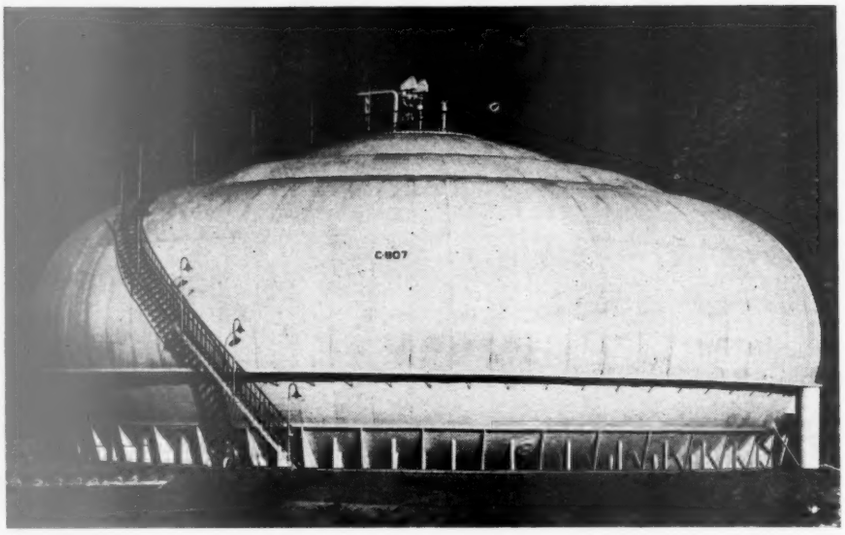


FIG. 7. Noded Hortonspheroids such as this permit a large volume of product to be stored in a single unit.

It will pay to go one step further and establish a definite procedure for the inspection and maintenance of all fittings. A tank relief vent that operates at a pressure or vacuum of several inches of water is not very positive in operation because the force available to raise and lower the pallet is exceedingly small. A few particles of debris or frozen drops of moisture on the valve seat or the guides may cause the pallet to stick either open or shut. It is highly important, therefore, to check the operation of all fittings each few days. As a further precaution, it is a good idea to install a recording gage that will provide a permanent record of the pressure or vacuum existing in the system at all times. A glance at the chart will show immediately whether the system is functioning properly and a search to find the source of trouble can then be made without delay if it is not.

It may be that you prefer a pressure storage system to a vapor saving system employing a low pressure gasholder in the form of a Lifter Roof or a Vaporsphere. In the pressure storage method, breathing losses are stopped by keeping all products in vessels designed to withstand the maximum vapor space pressures developed by the stored liquid at the highest temperature reached by its surface. So long as the internal pressure does not reach the value at which the relief vents open, there can be no venting and consequently no evaporation loss or change in the quality of the stored product.

All pressure vessels in the group that have the same operating pressure may be interconnected by vapor lines to take advantage of the reduction in filling loss that is possible when the rate of filling is equal to the rate of emptying. At all times when the vapor space pressure in the system is below the venting pressure, a differential pressure cushion is available for use in preventing the filling losses that would otherwise result from unbalanced filling and emptying.

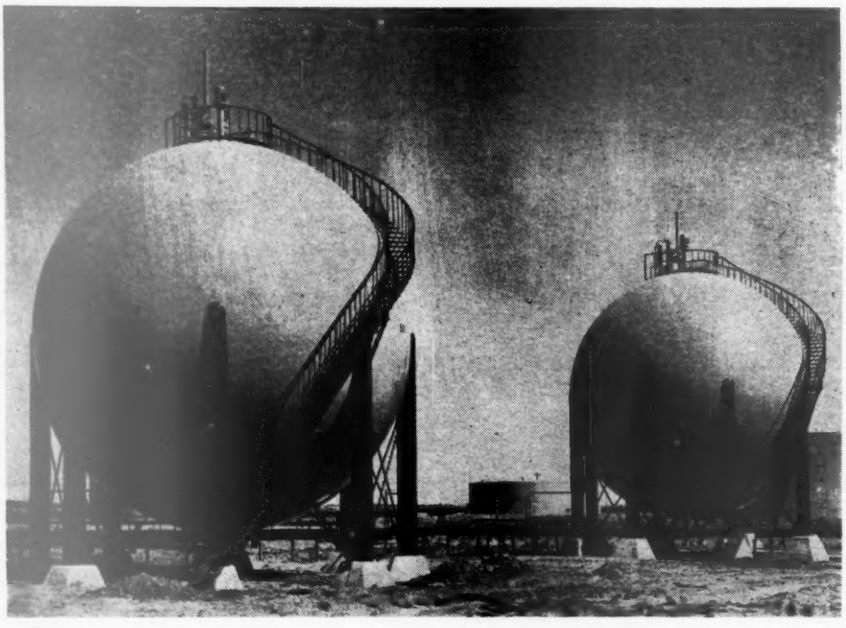
In cases where the balance between filling and emptying is poor, the effectiveness of a pressure vessel system in preventing filling losses can be increased appreciably by adding a Vaporsphere into the system in the manner shown in Fig. 3. The relief vent on the air side of the membrane in the Vaporsphere is set to open at a slightly lower pressure than the relief vents on the pressure vessels. This insures that the Vaporsphere will fill with vapor before any venting takes place from the storage vessels. Similarly, the vacuum vent on the air side of the Vaporsphere membrane is adjusted to open at a slightly lower partial vacuum than the vacuum vents on the tanks to insure that the contents of the Vaporsphere will reenter the tanks before any air is drawn into the system.

We have already mentioned the kind of terminal where all tanks are filled at one time and then emptied slowly over a long period of time. Where such conditions prevail, a pressure storage system provides a more satisfactory solution to the storage problem than a vapor saving employing a low pressure gasholder. When a tank operating at or near atmospheric pressure is emptied, the volume of the air-vapor mixture expelled from the vapor space each day gradually increases as the liquid level falls. This means that a Lifter Roof or Vaporsphere of extremely great capacity would have to be provided to prevent all breathing loss.

A different condition prevails in a pressure tank. It is a well-established fact that the amount of pressure required to eliminate venting depends on the volatility of the stored product and the temperature variations of the vapor space and the liquid surface. It is not a function of the *volume* of the vapor space. For this reason, a given amount of pressure is just as effective in preventing loss from a partially filled vessel as it is in preventing loss from a full one. It follows that a pressure container has the unique characteristic of operating at full efficiency throughout its entire range of capacity. When products of high value are to be stored and the tanks are to be operated throughout their entire capacity range, pressure vessels, such as 2½ lb. Hemispheroids and 2½ lb. Hortonspheroids, may provide the lowest cost storage that can be obtained. As a rule, 2½ lb. Hemispheroids are used for capacities from 2500 bbl. to 30,000 bbl.; 2½ lb. Hortonspheroids are used for capacities above 30,000 bbl.

Thus far we have confined our discussion to the storage of motor gasolines and similar products, which do not boil at normal tank liquid temperatures. Pressure containers provide the only sat-

FIG. 8. Hortonspheres with new type tubular columns provide the best means of storing high vapor pressure products.



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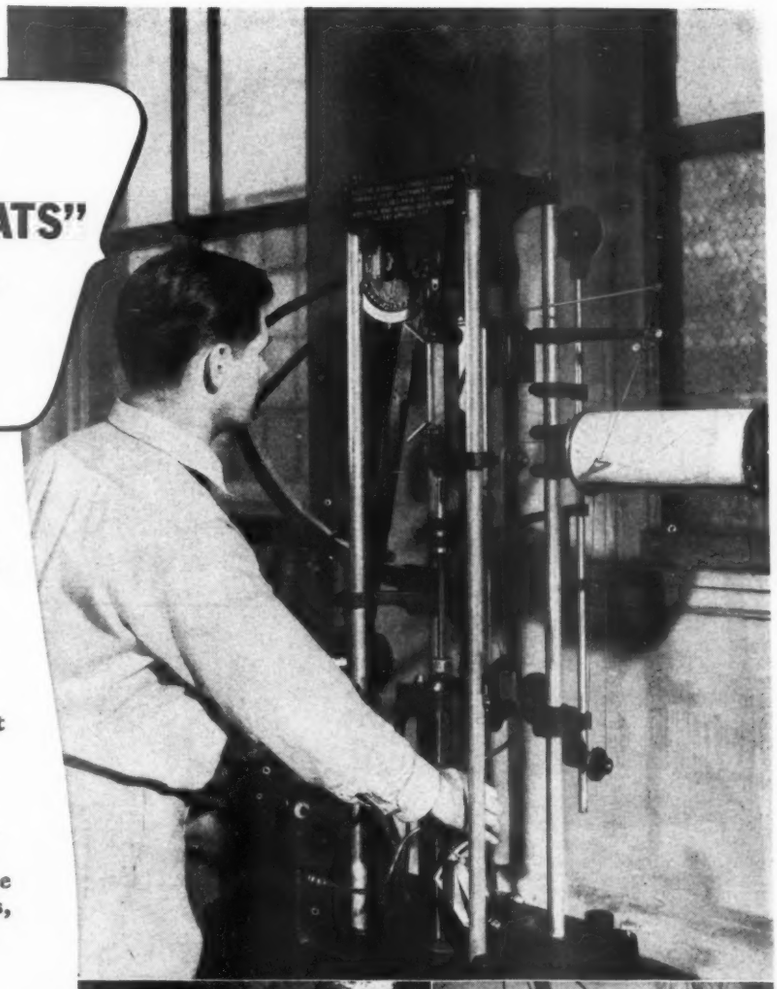

Scientific tests of NO-OX-IDized wrapper during the various stages of manufacture assure excellent performance when the wrapper "overcoats" your pipe lines against moisture penetration and corrosive soil action.

In the illustration on the right, the technician tests the chemically impregnated wrapper for tensile strength . . . makes sure that it possesses the inherent structural stability to prevent breakdown during application and to resist deformation in service.

NO-OX-IDized wrapper, used in conjunction with NO-OX-ID, the *original* rust preventive, guards underground pipe and service lines in highly corrosive soils, in ditches which serve as drains for salt water, or under cinders where the life line of a pipe is usually a short one.

Complete data on NO-OX-ID's mechanical and chemical protective qualities will be sent on request.

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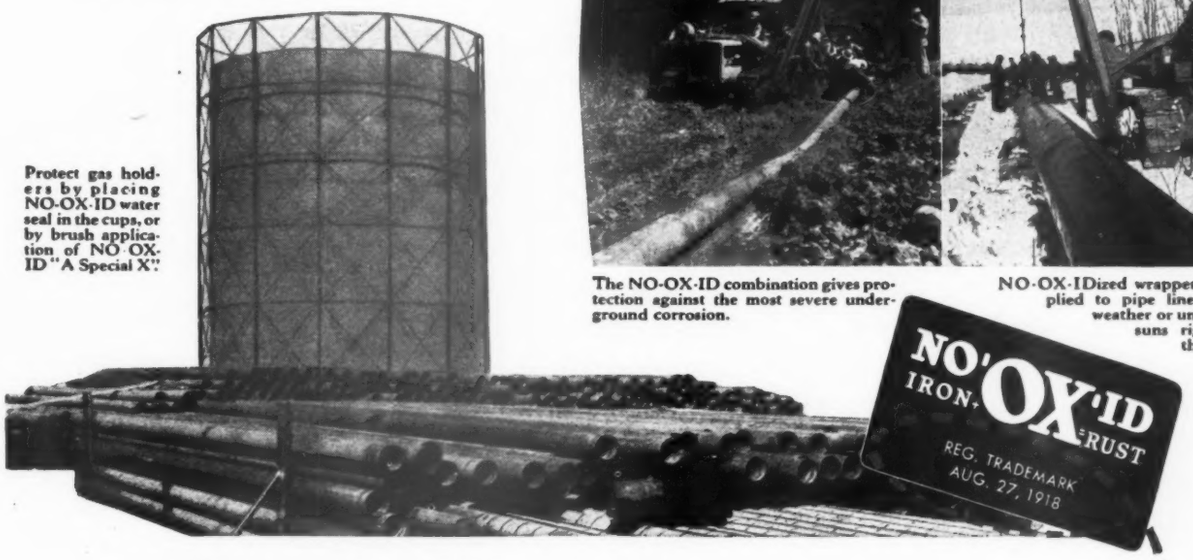

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1. Does the roof have sufficient buoyancy and floating stability to remain afloat and reasonably level under all weather and operating conditions to which it may be subjected? If it does not, it may sink.
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3. Does the float insulate the liquid from the heat of the sun? If it does not, the stored product may boil during the hot part of the day with heavy resultant loss.
4. Does the top of the float deck have a positive downward slope toward the drain at all points? If it does not, rain water will collect in the low spots causing deterioration of the paint and eventual corrosion.
5. Is the entire underside of the deck in contact with the liquid when the roof is floating? If an air space exists between the liquid and the bottom of the float, accelerated corrosion may shorten the useful life of the roof.

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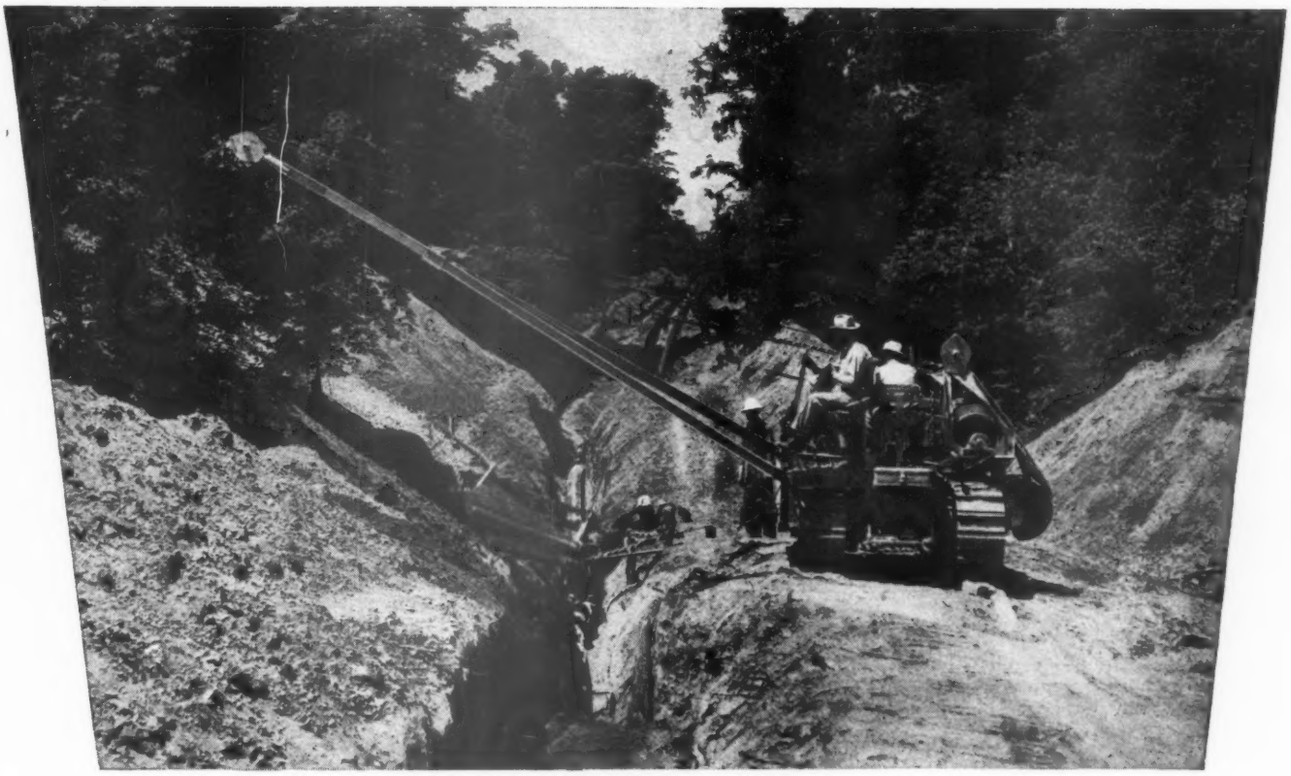

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MEASUREMENT OF CATHODIC PROTECTION CURRENTS IN SUBMARINE PIPE LINES

By **W. RYLAND HILL,** Department of Electrical Engineering,
University of Washington, Seattle

IN THE cathodic protection of a submarine pipe line there arises the problem of determining the protection obtained. Although the effectiveness of the system is eventually recorded in terms of the pipe corrosion and leak record, it is highly desirable to make measurements at the time of installation and at periodic intervals afterward which, together with laboratory studies and observations on similar lines, provide an estimate of the protection being obtained. With submarine lines this is particularly difficult because few points on the line are available for direct observation or electrical measurement.

EXCLUSIVE

Cathodic protection of a submarine line probably depends upon the maintenance of a sufficiently large protective current density entering the pipe surface at all points along the line to reduce corrosion to a standstill. The amount of current required to do this depends on the conditions to which the line is exposed; for sea water a value of 100 milliamperes per sq. ft. has been reported to protect steel against corrosion in laboratory tests.* Consequently measurement of protection on a submarine line resolves into the problem of determining the current density at the pipe surface.

● **The problem.** The particular problem to be discussed here is that of estimating the minimum current density entering a submarine pipe line. As the current distribution on such a line is ordinarily non-uniform the minimum current density assumes greatest importance; if at this point protection occurs the rest of the line will be safe.

The specific type of line to be studied is shown in Fig. 1, which represents a uniform submarine pipe line extending out to an anchorage at sea. Such submarine loading lines occur on the California and Gulf coasts and at other points where it is impracticable to build wharf facilities for tankers. Usually the lines are several thousand feet long and repair is so difficult that cathodic protection is justified. The cathodic protection system commonly consists of an anode placed some distance from the short end of the pipe line, a rectifier or other source of direct current, and the necessary connecting cables.

The only convenient electrical measurements that can be made on the system are: (1) Determination of the current at point *A* at the shore end of the line, and (2) measurement of the total voltage drop between the sea end of the line *B* and the shore end *A*. The voltage drop between *A* and *B* can be made by using the telephone laid with the pipe line for ship-to-shore communication. These two measurements together with the chart of Fig. 4 permit a reasonable estimate of the minimum current density at the sea end of the line.

Two electrical measurements determine the minimum protective current density on a submarine pipe line.

● **Analysis of the problem.** The basis for this analysis is that the total voltage drop along the line depends not only on the total current drawn from the line but also on the distribution of the current pickup along the line. For example, each ampere entering the pipe surface near *B* travels the full length of the pipe and produces a much greater voltage drop in the line than an equal current entering the line near the shore end. Consequently, for a given current at *A*, a large total voltage drop indicates that a large share of the current enters the pipe line near the outer end, whereas a small drop indicates that the sea end receives little current.

The total voltage drop in the line between *A* and *B* is the sum of all the voltage drops of each little increment of line length. Mathematically stated.

$$E = \int_0^L I\,R\,dx = R\int_0^L I\,dx \qquad (1)$$

Where:

E = the voltage drop between *A* and *B*,
x = the distance out from point *A*,
R = the resistance per unit length of line,
R dx = the resistance of an elemental length of line,
I = the current flowing in the pipe at distance x, and
L = the total length of line between *A* and *B*.

The factor $\int_0^L I\,dx$ of equation (1) can be interpreted as the *area* under a

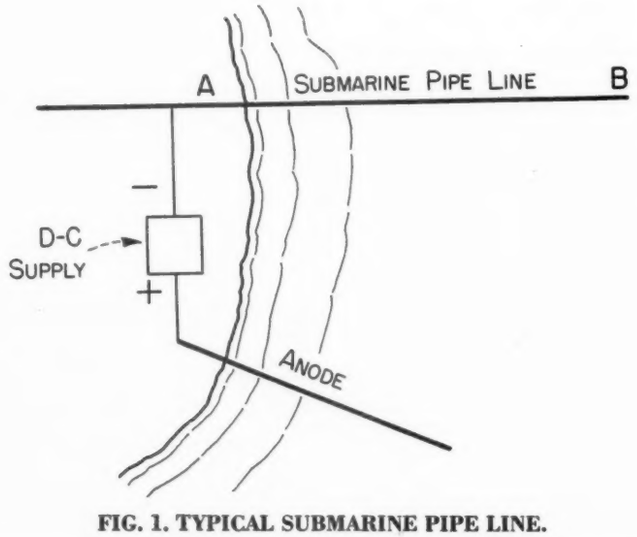

FIG. 1. TYPICAL SUBMARINE PIPE LINE.

*"Laboratory Tests of Cathodic Protection of Steel in Various Corrosive Solutions," by W. Ryland Hill, *The Petroleum Engineer*, September, 1941.

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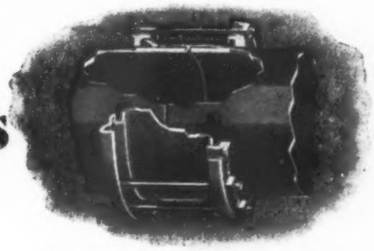

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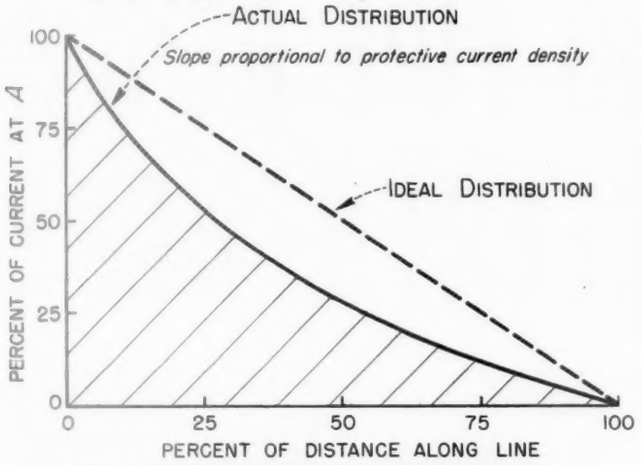


FIG. 2. TYPICAL CURRENT DISTRIBUTION.

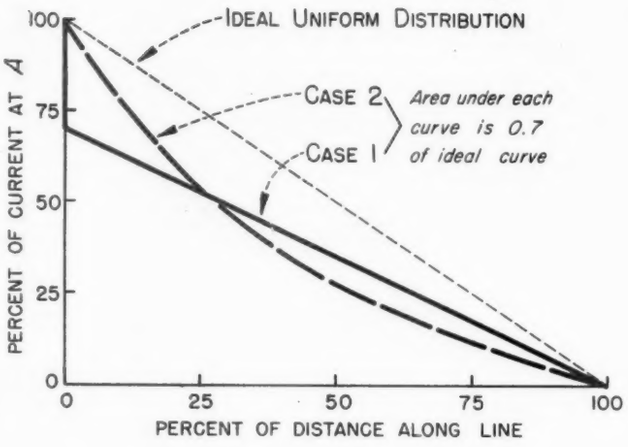


FIG. 3. LIMITING DISTRIBUTION CURVES.

current vs. distance curve. Therefore equation (1) tells us that the voltage drop in the line is proportional to the area under the current distribution curve. The solid curve of Fig. 2 shows a typical current distribution curve for a submarine line, expressed in terms of per cent total current and distance. The cross-hatched area is proportional to the voltage drop *E*. The *slope* of the curve at any point equals the rate of gain of current by the line (amperes per unit length) and therefore is proportional to the protective current density entering the pipe surface. The curve of Fig. 2 represents a typical condition of maximum protective current density at the shore end with decreased current pickup at the sea end. This is caused partly by the proximity of the anode to the shore end and partly by the voltage drop along the line, which makes the anode-to-line potential greater near the shore end.

The ideal condition is shown by the dotted line, which represents uniform current pickup by each section of the line and therefore uniform protective current density throughout the line length. The area under the dotted curve is *greater* than that under the typical curve, and the voltage drop produced by ideal protection exceeds that produced in an actual installation. If we can compute the voltage drop that would have been produced by the ideal system and compare it to the actual measured voltage drop we shall then have a means of estimating the current distribution. This can be done.

The preceding analysis shows that a comparison of the actual line voltage drop to the ideal one provides a measure of the current distribution. Let us call the ratio of actual to ideal voltage drop the *distribution factor*. A factor of one indicates that the protective current density is uniform; a low factor indicates that the current density at the far end is below the ideal value. *How much lower* depends on the shape of the current distribution curve, for there are a large number of curves different from that shown in Fig. 2 yet enclosing the same area.

The next step is to investigate the shape of the current distribution curve for a typical pipe line to obtain a correlation between the measured distribution factor and the minimum current density at the sea end of the line. A study of the situation shows that for the system shown by Fig. 1 for a pipe in a relatively homogenous medium with the anode nearer the shore end of the line than the sea end, the current gain invariably increases toward the shore end. This is substantiated by field observations. For this reason the curve of Fig. 2 must always *increase* in slope toward the left.

We shall now investigate two limiting cases that will establish limits for use in estimating minimum current density.

(1). Case of greatest minimum. For the purpose of illustration let us assume a distribution factor of 0.7 for a particular line. This means that the area under the actual current distribution curve is 0.7 of that under ideal curve. Now we wish to construct a curve having (a) maximum slope at the right end, (b) an area 0.7 times that of the ideal curve, and (c) a constant or increasing slope to the left. This is shown by the straight line for Case (1) in Fig. 3, which fits all the stated requirements. Such a curve represents an extreme case in which the pickup is uniform along the line except at the shore end where a large current is gained in a short distance. This condition is approached with small pipe-to-anode distances.

The slope of Fig. 3, Case (1), curve is 0.7 times that of the ideal curve. In general for the condition illustrated the minimum protective current density is equal to the ideal current density multiplied by the distribution factor. This gives the upper curve for the chart of Fig. 4.

(2). Case of least minimum. For a given enclosed area the minimum slope at the right end will be obtained when the curve drops off as slowly as possible at the left end. This is shown by Fig. 3, Case (2), and represents in practice an extremely distant anode location that eliminates excessive current densities entering the shore end of the pipe and reduces the slope of the curve toward the left. In this case the current distribution is affected principally by the voltage drop in the pipe line. This problem can be solved mathematically with the following result:

$$I = I_A \frac{\sinh (L - x) \propto}{\sinh L \propto} \quad . \quad . \quad . \quad (2)$$

Where:

I_A = the current at point *A*,

I = the current at distance x out from *A*,

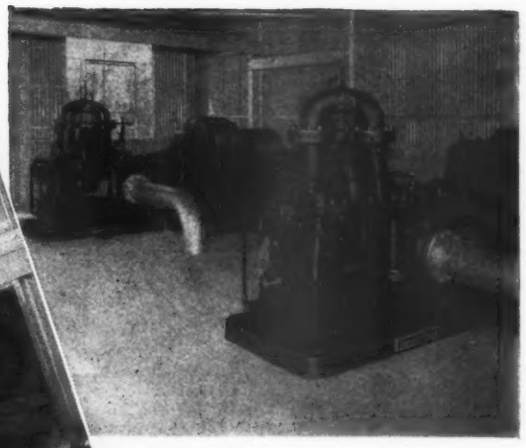
L = the total length of line, and

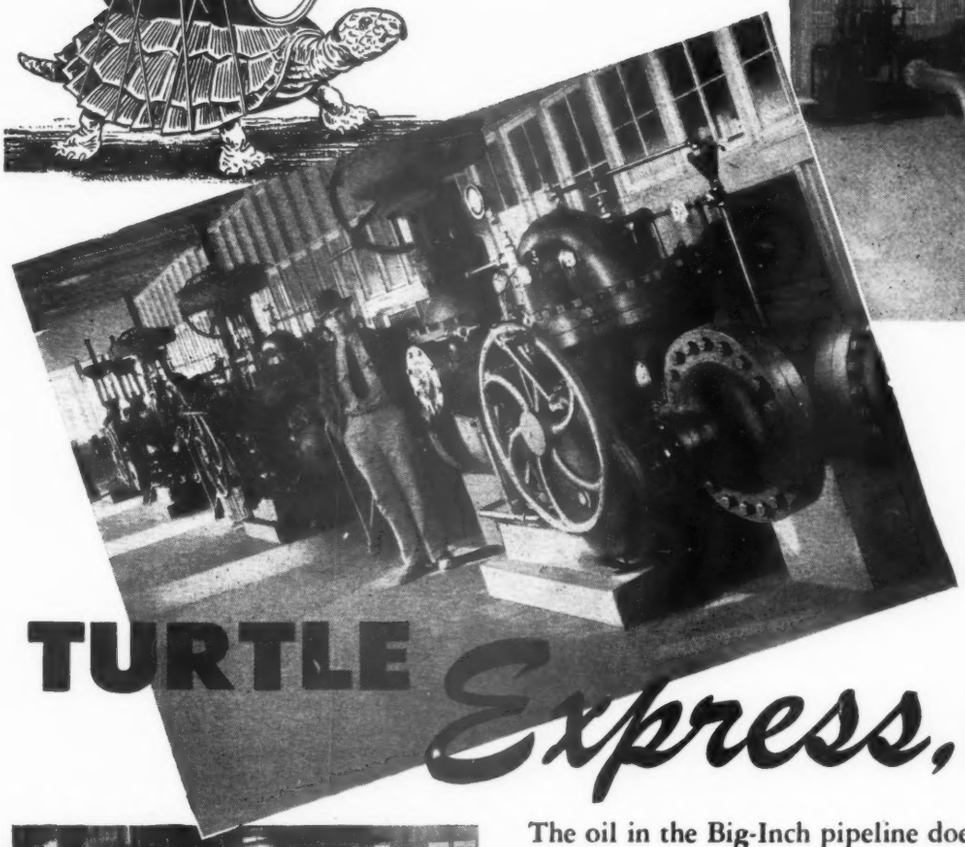
$\propto$ = a constant depending on the pipe resistance and the pipe-to-sea resistance.

The curve of Fig. 3 shows an accurate plot of this equation for a distribution factor of 0.7. By differentiation the slope of this curve at the right end can be obtained and compared to the ideal uniform case for different values of alpha. By intergration the area under it can be compared to the ideal case to find the corresponding distribution factors. The lower curve of Fig. 4 shows the result of carrying out these processes.

Unless the foregoing analysis is carefully followed an erroneous conclusion may be drawn. Reference to Fig. 3 shows that for a given distribution factor Case (1) gives a higher current density at the sea end of the pipe than does Case (2). As Case (1) represents an anode close to the shore end of the pipe, it might seem that moving the anode away from the pipe line to give better distribution is undesirable. This is not so. For a *given distribution factor* the local anode does represent better protection but in actual practice a more remote anode results in a *higher distribution factor*. This higher distribution factor more than offsets the difference between Cases (1) and (2), resulting in better protection with a distant anode.

● **Sample problem.** The chart of Fig. 4 shows the relation between the distribution factor and the minimum current density for the limiting conditions of Cases (1) and (2) and for an average estimate between them. To use the chart two electrical measurements must be known: (a) The total voltage drop in the line between *A* and *B*, and (b) the voltage drop in a measured length of line at point A. From these the distribution factor and average protective cur-





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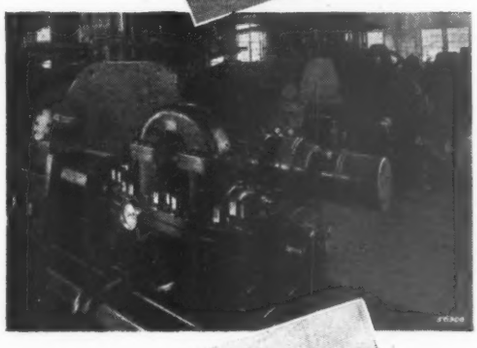

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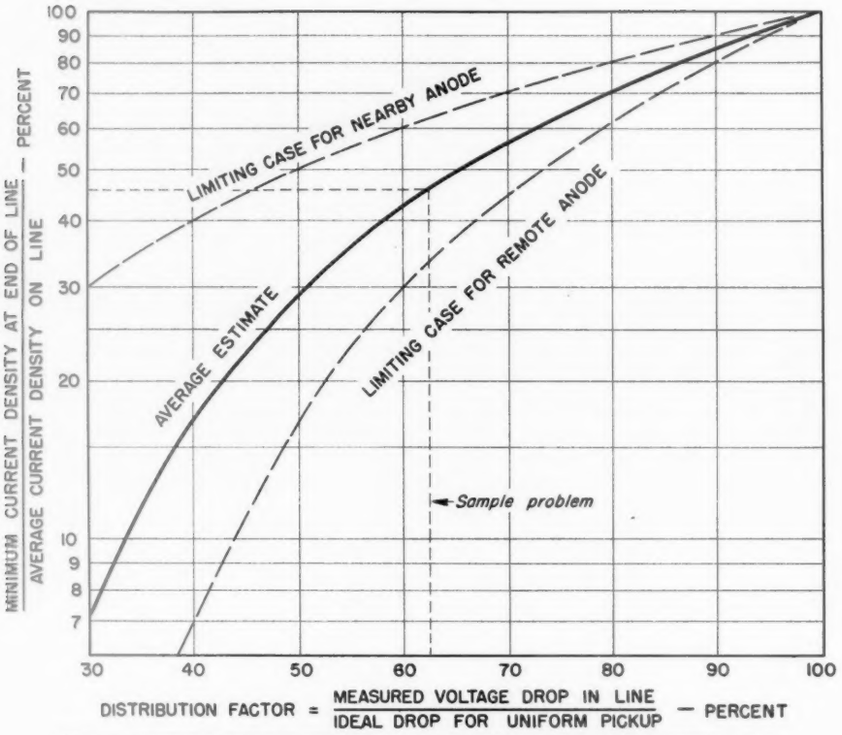

FIG. 4. CURVES FOR ESTIMATING MINIMUM CURRENT DENSITY.

rent density are computed. Then by reference to the chart the minimum current density on the line can be estimated. A sample problem will help to illustrate the procedure followed in using Fig. 4.

Assumed test data

Line—2000 ft. of 16-in., 90-lb., steel pipe

Voltage drop in 30 ft. of pipe at A — 12 mv.

Voltage drop in pipe between A and B — 0.25 volt

(1). Current at A. The pipe current at A can be computed by using the formula:

$$I = \frac{(\text{millivolts drop})\ (\text{weight per foot})\ (K)}{(\text{length of test section})} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

The factor K depends on the pipe material and varies with the carbon content of the steel. Factor K can be determined experimentally by testing a pipe sample with a known current. Assuming that K is 4 for this problem:

$I = (12)\ (90)\ (4)/(30) = 144$ amp.

The current could also be determined by reading the current output of the direct-current supply, together with voltage drop readings in equal sections of pipe either side of the drainage point to measure the fraction flowing from each side.

(2). Average protective current density. The average current density entering the pipe is equal to the total current divided by the total surface area.

$$\text{Density} = \frac{144}{(2000)\ (\ )\ (16/12)}$$

$= 0.017$ amp. per sq. ft.

(3). Voltage drop for uniform pickup. For an initial current of 144 amp. tapering off uniformly to zero at the sea end the voltage drop would be just one-half that obtained if the full 144 amp. flowed the entire distance. However, if a current of 144 amp. produces 12 mv. drop in 30 ft., by proportion it would produce

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Ideal drop for uniform pickup = (2000) (0.012)/(30) (2) = 0.4 volts.

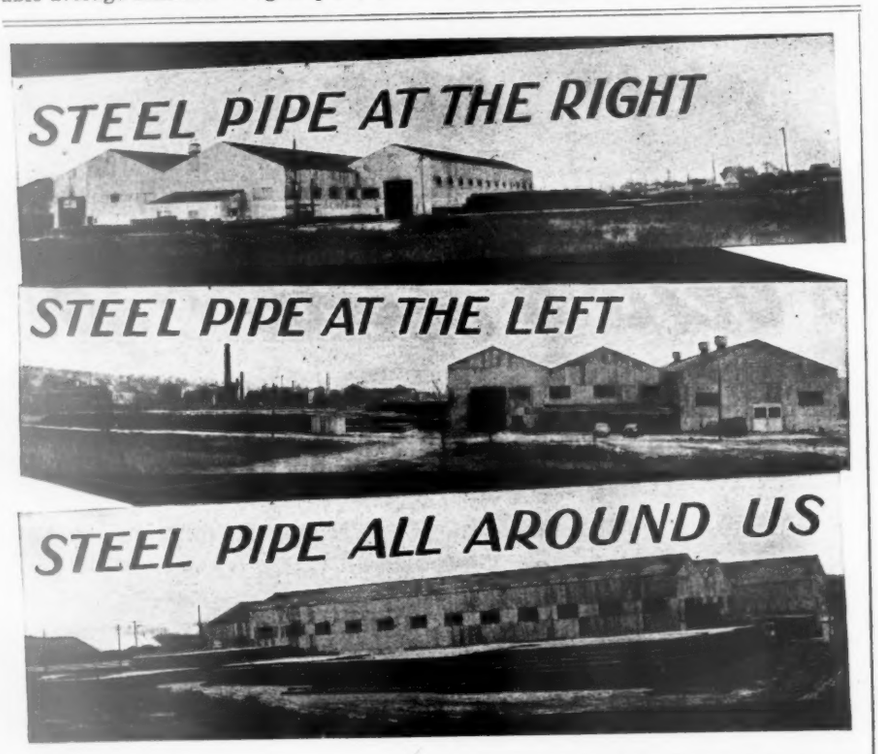
(4). Distribution factor. The distribution factor is defined as the ratio between the measured drop in the pipe to the ideal drop for uniform pickup. Therefore:

Distribution factor = 0.25/0.4 = 0.625 or 62.5 per cent.

(5). Minimum protective density. Reference to Fig. 4 shows that for a distribution factor of 0.62 the ratio of minimum to average current density is between the limits of 0.2 and 0.33 with a reasonable average estimate being 46 per cent. The estimated minimum current density is then:

Minimum density at end of line = (0.46) (0.017) = 0.0078 amp. per sq. ft.

The chart of Fig. 4 shows that for low distribution factors the uncertainty in estimating the minimum current density increases. This is an unfortunate natural consequence of the fact that only two electrical measurements are obtainable for solving the problem. The distribution factor itself is of use for correlating the performance of different cathodic installations and for observing changes in a given system, however. Periodic measurements on an installation will readily indicate whether the distribution is becoming better or worse. Likewise observation of the distribution factor before and after the installation of a new anode will serve to measure its effectiveness.



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APPENDIX

● **Current distribution for remote anode.** For a uniform pipe in a homogeneous medium receiving current from a remote anode, the current distribution is affected only by the voltage drop in the pipe line, not by the anode position. To a first approximation the current enters the pipe surface radially and the majority of the voltage drop between the pipe and a remote point in the surrounding medium takes place near the pipe surface where the current density in the medium is greatest. In fact, field measurements in soils show that most of the voltage drop between pipe and distant soil takes place in the first 20 or 30 pipe diameters measured radially outward. Consequently we can simplify the problem to that of a cylindrical pipe surrounded by a concentric equipotential cylinder of considerably greater diameter with current flowing radially inward to the pipe.

The following differential equations can be written for the simplified problem:

$$dI = E\ G\ dx \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

$$dE = I\ R\ dx \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

Where:

X = the distance out from point A,
R = the resistance per unit length of pipe,
G = the conductance between pipe and equipotential cylinder per unit of length,
I = the current in the pipe at x, and
E = the potential difference between pipe and cylinder at x.

Differentiating equation (4) and substituting equation (5) into the resulting expression gives:

$$d^2I/dx^2 = IGR \quad . \quad . \quad . \quad . \quad . \quad . (6)$$

This has a solution of the form $I = A\ e^{mx}$. Substituting this solution into equation (6) and solving for m gives $m = \pm \sqrt{GR}$. The complete solution for equation (6) is therefore:

$$I = A_1\ e^{\sqrt{GR}} + A_2\ e^{-\sqrt{GR}} \quad . \quad . \quad (7)$$

To find the A's the boundary conditions must be inserted. At the shore end of the line when x = O, $I = I_A$. At the sea end x = L and I = O. By substituting first one set and then the other into equation (7) two equations are obtained that can be solved simultaneously for the A's.

Performing this operation and substituting the values obtained into equation (7) we obtain the final equation for the current distribution curve:

$$I = I_A \frac{e^{(L-x)\sqrt{GR}} - e^{-(L-x)\sqrt{GR}}}{e^{L\sqrt{GR}} - e^{-L\sqrt{GR}}}$$

$$= I_A \frac{\sinh\ (L-x\sqrt{GR}}{\sinh\ L\sqrt{GR}} \quad . \quad . \quad . \quad (8)$$

In writing equation (2) the factor $\sqrt{GR}$ of equation (8) has been replaced by the symbol $\propto$. ★ ★ ★

Reprints of this article may be obtained without cost by addressing the Engineering Experiment Station, University of Washington, Seattle 5, Wash.

FIG. 1. First step is blasting right-of-way.

FIG. 2. Pipe sections laid out along spread.

CURRENT PROCEDURES IN PIPE LINE WELDING

By **A. F. DAVIS**
Vice President
The Lincoln Electric Company

EXCLUSIVE

CONSTRUCTION of thousands of miles of pipe lines by the modern process of arc welding has proved to be one of the nation's most outstanding achievements during the past several years.

Welding procedures as carried out today have reached a new point in economy due largely to the efforts of the country's leading pipeline contractors in working out better methods for use in the field.

Stovepipe or bell-hole welding for example, is now generally used in line construction due to the important savings it effects in welding production time. With stovepipe welding, the cost of transportation of equipment is reduced about 50 per cent due to the use of smaller and lighter welding machines. For instance, welders of 200-amp. capacity are used in "stovepiping" instead of the 400-amp. units required for the former roll-welding method.

Among other advancements that have facilitated and improved the work of pipe-line fabrication has been the advent of the inside line-up clamp as applied to large diameter pipe having thinner wall sections. The use of such pipe, which is made of greater strength steel, is becoming more widespread due to its lighter weight and the greater ease with which it can be handled.

This special clamp is expanded hydraulically to form an even circle against the inside walls of the pipe sections, thus

FIG. 3. "Trenching" a pipe line.

FIG. 4. Below, applying the first, or stringer beads.

FIG. 5. Typical pipe line bend made to suit terrain.

FIG. 6. Tractor lining up pipe section.

FIG. 7. Applying finish weld on pipe section.

FIG. 8. Weld fabricated line lowered into trench.

permitting a smooth uniform joint. Welding operations therefore can be speeded up as there are no obstructions such as outside clamps around the pipe joints. This also eliminates tack welding the joints as formerly required before finish welding.

The inside line-up clamps can be assembled or knocked down in a few minutes for transportation from one job to another.

In regard to the more or less standardized practice of stovepipe welding, the procedures usually adopted comprise:

(a) Clearing and blasting the right-of-way of obstructions (Fig. 1), then the pipe sections are laid out along the spread on the leeward side (Fig. 2), adjacent to pile of earth and stone removed from the trench. This eliminates crossing and recrossing the pile during subsequent welding operations.

(b) The trench is then dug with a modern trencher (Fig. 3), as far as one-half mile ahead of the welding crew.

(c) Pipe is laid over the trench on timber skids, lined up at the joint, and stringer beads are applied by two welders (Fig. 4). The first (stringer) bead is made so that 100 per cent penetration is obtained at each pipe joint.

(d) The sags or bends such as shown in Fig. 5, are then made to suit the contour of the terrain. Sometimes these pipe bends are prefabricated.

(e) The line-up crew picks up the next section of pipe to be tied into the line. (Fig. 6). This work is done with one or two tractors.

(f) The finish bead is then applied (Fig. 7) using mild steel shielded arc electrode in ⅛-in., 5/32-in., or 3/16-in. size.

(g) The completely welded pipe is then lowered into the trench (Fig. 8), allowing sufficient slack in the line to suit conditions of the terrain.

Welding speeds obtained by average welders on typical lines such as those of 12 in. diam. are from 26 to 30 welds per 9-hr. day, although greater speeds frequently are made under ideal conditions. ★ ★ ★

CLEAR RIGHT-OF-WAY WITH ROTARY SAW

Rapid felling of trees and heavy brush in East Texas expedites laying pipe line from Opelika to Carthage

Turned horizontally the saw cuts down large trees with speed and a minimum of effort.

SIXTY miles of dense East Texas pine timber and brush have been "mowed" down to clear the way for an 80-mile 14-in. gas line that Lone Star Gas Company is laying from Opelika in Henderson County to a point near Carthage in Panola County. The heavy timber gave the Oklahoma Contracting Company a problem but it was solved by the use of 4 motorized rotary saws known as Little Giant Tree Fellers. These saws cut through the forest in record time so that the right-of-way was cleared by mid-February.

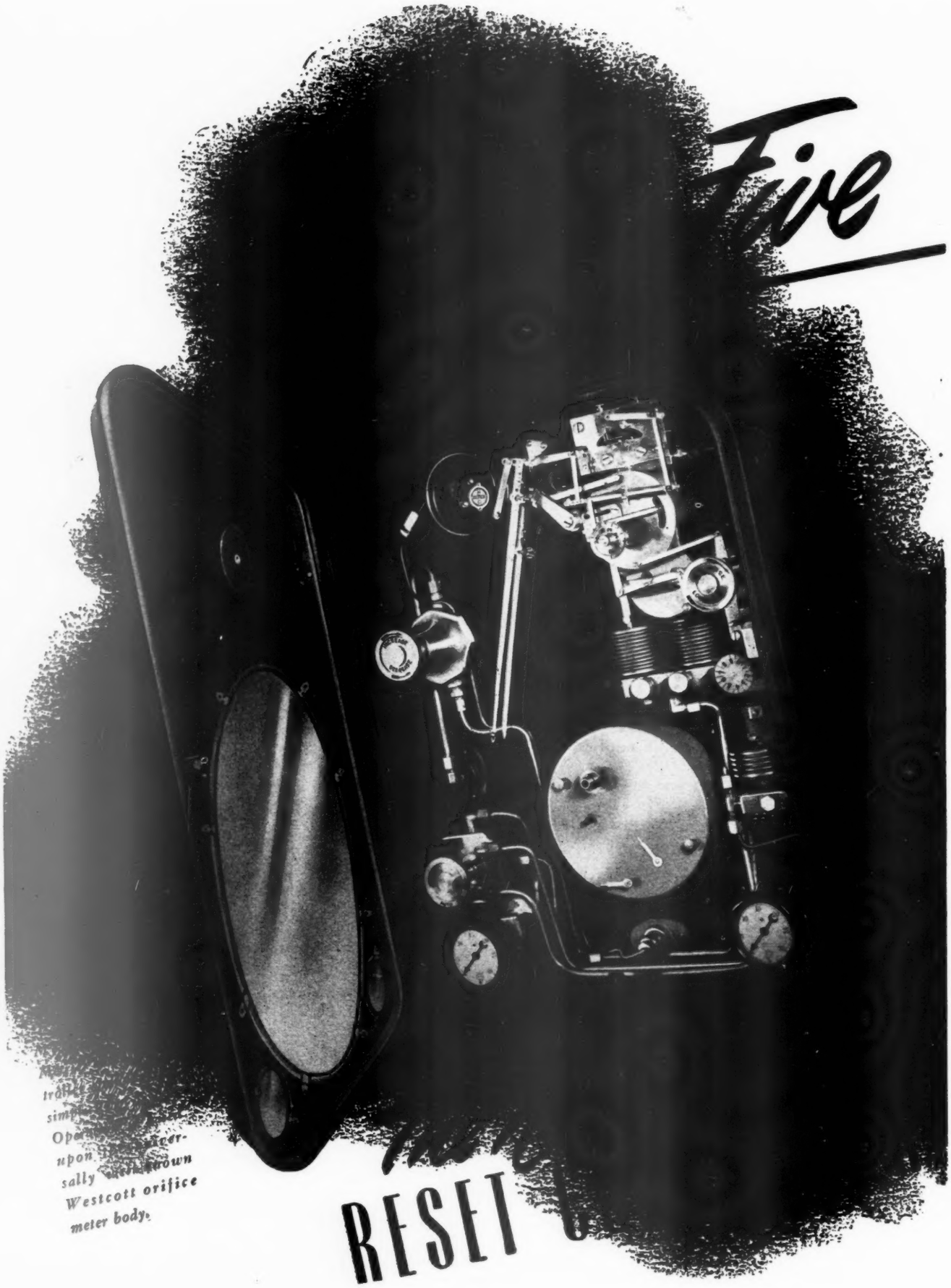
The new line will carry gas from the Carthage field to join the company's present pipe line net work at Opelika.

Also under construction by the company 8 miles north of Carthage is a cycling plant that will tap one of the large gas-condensate fields in that area. This plant, jointly owned by Lone Star and Rogers Lacy of Longview, will be operated by Lone Star Producing Company. The plant will have a capacity for processing 50,000,000 cu. ft. daily and a further initial capacity of 50,000,000 daily for pipe line delivery. Cycled gas will be returned to the producing formation.

Lone Star Producing Company is to build another cycling plant in the Chapel Hill area near Tyler. ★★★

Little Giant Tree Feller saw at work clearing timber such as that found on gas pipe line right-of-way.

Five



Mo... trol... simp... Ope... upon... sally ... Westcott orifice meter body.

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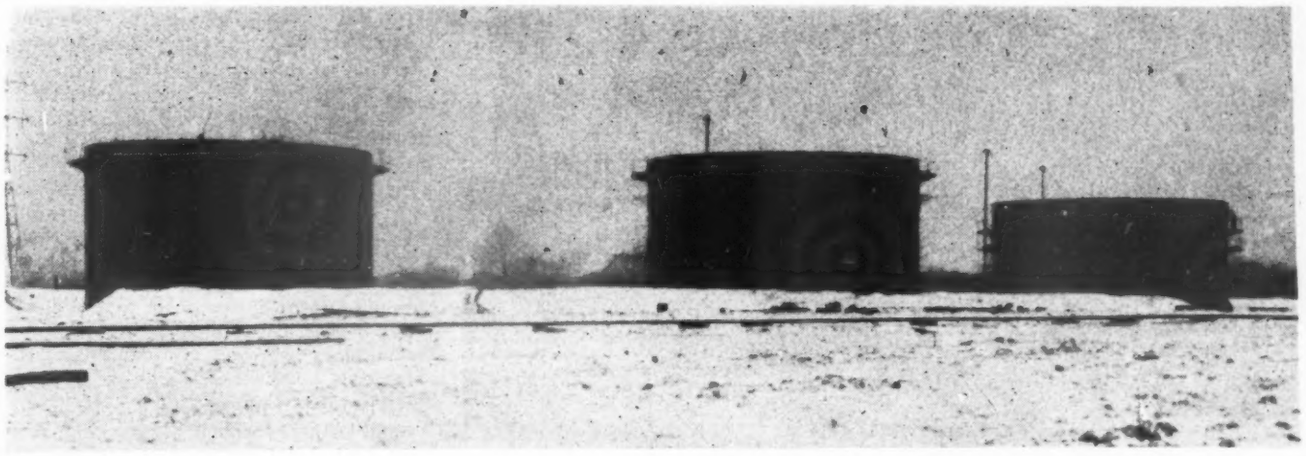


Three of the 38-year-old tanks in the process of being cut down.

PIPE LINE TERMINAL DISMANTLED, SALVAGED

By **T. H. MENAUGH,** Graver Tank and Manufacturing Company, Inc.

To conserve scarce materials, one terminal was dismantled and, with addition of certain new steel, two new installations made.

How to proceed with the expansion of its distributing system in the face of wartime difficulties was the problem that faced the Ohio Oil Company in the summer of 1944.

EXCLUSIVE

When the final answer to this problem was evolved, it was based upon the conservation of three materials so vital to the nation's welfare at that time: Steel, lumber, and gasoline vapor.

Here is what the job amounted to. One existing terminal was dismantled and the salvaged material was refabricated and reassembled, with the addition of new steel, to create two new installations possessing the latest equipment, including tanks especially designed to conserve vapors in storage. The field and construction divisions of the Graver Tank and Manufacturing Company, Inc., were called in from East Chicago, Indiana, to do the job.

At Martinsville, Illinois, there had been constructed in 1906 and 1907 a terminal consisting of 210 storage tanks of riveted construction, plus, of course, the necessary pumps and piping systems. Upon inspection it was discovered that some 20 of the original tanks had deteriorated through corrosion to a point where they no longer were satisfactory for storage. A number of them had been dismantled for a variety of reasons, but the remainder were available for their part in the program of expansion.

Specifications for the new system called for the storage of 236,000 bbl. at Indianapolis, Indiana, and 35,000 bbl. at Robinson, Illinois. The former was to include 10 tanks as follows: Two 55,000, six 20,000, one 5000, and one 1000 bbl. The latter was to have two 10,000 and three 5000-bbl. tanks.

Approximately 5000 of the used plates were found sufficiently well preserved to permit their use. Subtracted from the bill of material, this meant that an additional 350 tons of new steel would be required for the construction of conventional tank roofs, bottoms, roof supports, shell plating, and the expansion roofs. A government allotment provided for the purchase of this steel.

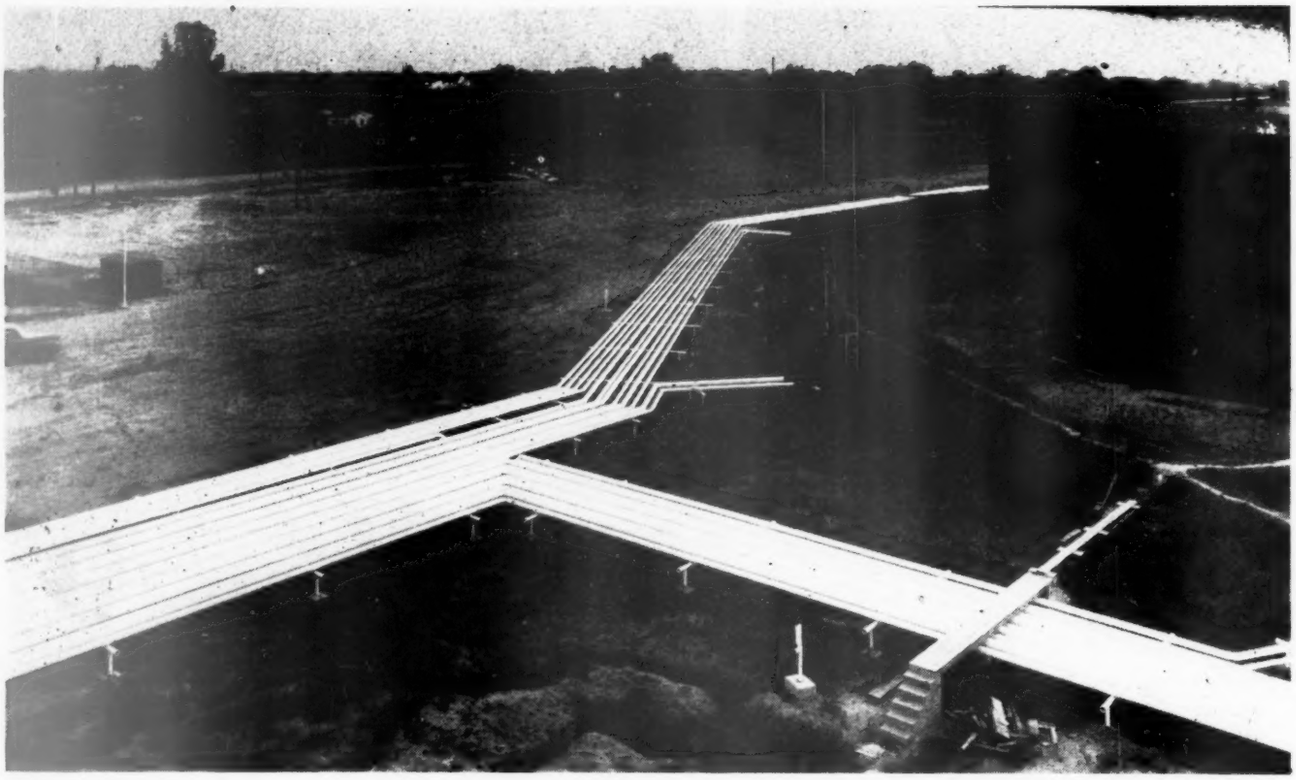
Dismantling the terminal and shipping the plates to Graver's plant for fabrication, then reshipping them to the new locations, would have imposed a considerable loss of time, expenditure of freight charges, and, something well worth considering during wartime, an unnecessary added load on the already overburdened railroads. To overcome this objection, it was decided to erect a temporary fabricating shop at Martinsville. Freight on the salvaged material was thereby reduced to 110 miles to Indianapolis and 50 miles to Robinson.

Building the fabricating shop itself was a simple matter as the necessary lumber came from the tanks as they were dismantled.

The task of dismantling the old tanks required 11 weeks and at the end of that time all the plate had been moved to the shop and was ready for the first operation there. Sorting was found to eliminate about 60 to 70 per cent of the bottom plates but all the shell plates were in good condition with the exception of a few of those from the first ring, which were rejected because of pitting at the ground line.

Construction of the shop was going on concurrently with the cutting-down of the old installation. Nineteen days after the start of construction, the first plate was being fabricated. While the field division was thus occupied at Martinsville, the construction division was at work at the two new sites preparing the tank grades, fire walls, building foundations, and laying out the piping systems.

As to the shop itself: Two bays were constructed, each 60 ft. long and 17 ft. wide with a 12-ft. ceiling. The right bay, as the plates entered, was reserved for shell plates and was equipped with two one-ton overhead hoists mounted so as to travel the length of the building. A burning table of sufficient size to accommodate 3 plates was provided along with a small capacity roll. The left bay had another traveling hoist, floor space for the laying out of roof and bottom



The piping system at Ohio Oil Company's Indianapolis installation, which provides for the interconnection between cone roof and expansion roof tanks. All pipe was fabricated on the job by the Graver company.

steel showed a tensile strength averaging 60,000 lb. per sq. in. and its weldability was equally good. All timbers used in building the shop were salvaged as well. Again, a considerable amount of freight handling was eliminated.

Conservation did not stop at this point, however, as the new terminals were designed to operate at the maximum effiency and with a minimum loss of gasoline vapors. Inspection of the accompanying photographs will show the arrangement of the 20,000-bbl. tanks manifolded with the two 55,000-bbl. tanks, which are equipped with the expansion roofs designed by the contractor. With this system it can be said that pumping out of storage (sales) is virtually equal to filling. Day-by-day readings will show an unbalanced condition between sales and receipts but this is accounted for in the 27,000-bbl. (152,000 cu. ft.) capacity of the expanding roofs. Through the manifold system, the two expansion-roof tanks are able to eliminate evaporation and filling losses from the entire battery. Vapors being displaced from any tank by incoming liquid are dispersed into the special tank's vapor space or into other tanks in the system from which withdrawal is being made. Not only does the roof protect against evaporation losses through changes in temperature but it also acts as a balancing agent for any difference in pumping between filling and removal.

A detail view of the burning table as tests were being run on the specially designed roller guide for the burner tip.

When they had completed the work at Martinsville, the Graver field division began erection of the new tanks at the two new sites prepared for them by the construction division. At Indianapolis the 10 tank grades and fire walls required the removal of 75,000 yards of dirt, and 1800 cu. yd. of concrete were poured for the building foundations, loading docks, and driveways. All piping for the system, which is considered one of the most efficient in operation today, was fabricated on the job by the contractor. The Indiana installation provides facilities for the servicing of 8 trucks and 5 tank cars. All work was accepted by the Ohio Oil Company in early summer 1945. ★★★

A Boost

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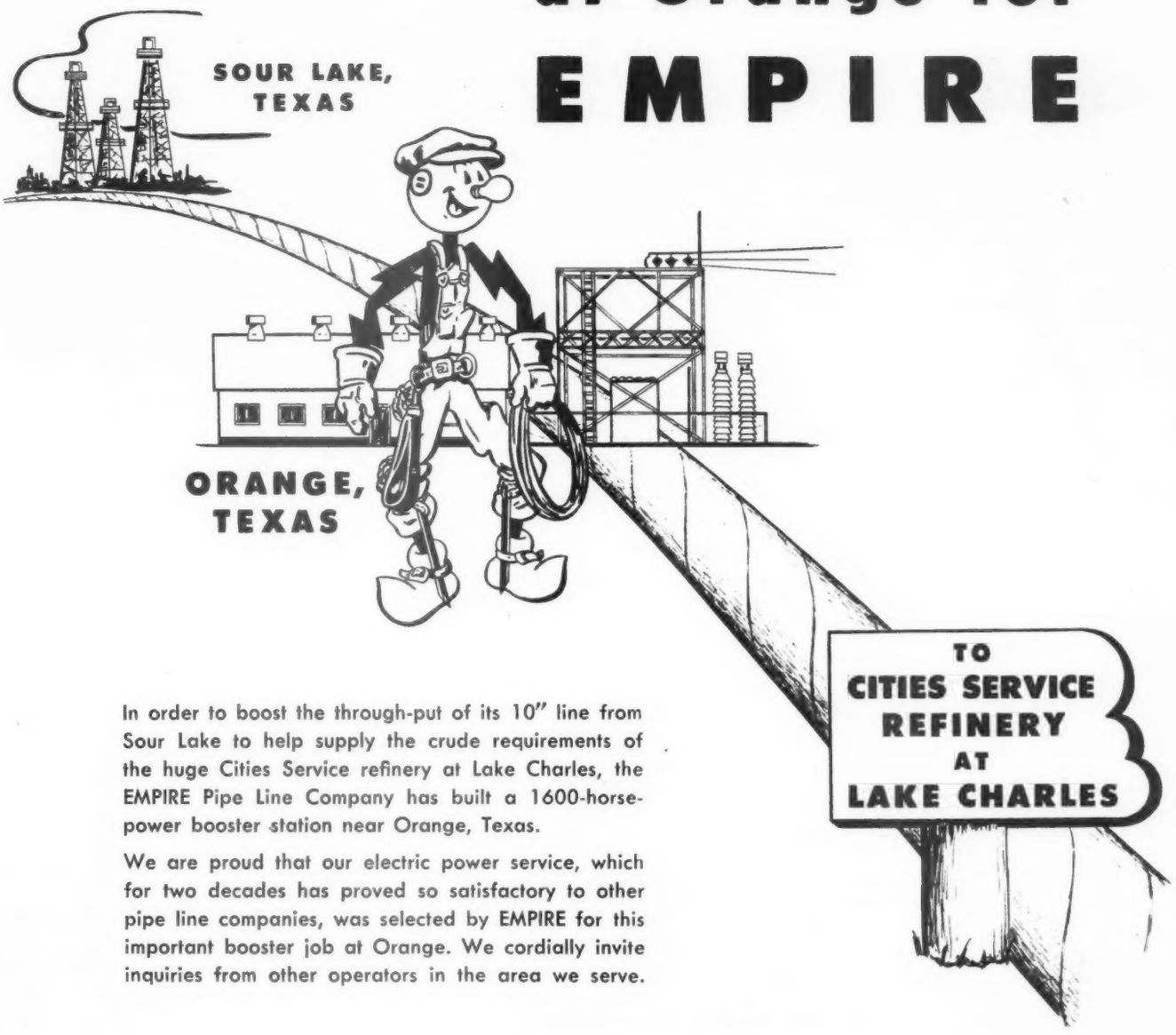

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SAFETY IN GAS PIPE LINE MAINTENANCE

By **A. W. BREELAND,** *Supervisor of Safety*
Lone Star Gas Company

IN THE gas pipe line industry more severe injuries occur from maintenance work than from construction and operation. In maintenance operations, workmen are exposed to about the same hazards as they are in pipe line construction, insofar as handling heavy material and operation of heavy machinery are concerned. Frequently much of the heavy equipment that is used in pipe line construction is used in maintenance work, particularly tractors, draglines, bulldozers, and heavy trucks, with the attendant hazards inherent in the operation of this equipment. The same material handling hazards exist as in construction except on a smaller scale. There are some peculiar or inherent hazards in gas pipe line maintenance, however, that cause considerable concern and are deserving of much time and attention.

EXCLUSIVE

In gas pipe line maintenance the most serious hazards are fires and blowouts and the major effort obviously should be directed toward the elimination insofar as possible of all conditions that might cause a fire and explosion, and at the same time preparations should be made to fight the fire successfully and to rescue and/or protect workmen in event the gas becomes ignited. This article therefore, will be limited, in large degree, to a discussion of these two hazards.

It goes without saying that efficient gas pipe line maintenance requires much planning and organization. There is no substitute for training and skill. Here is one job that requires a high degree of skill and judgment on the part of supervisors and the men who are to do the work.

Most serious hazards are fires and blowouts—Effort should be directed toward their prevention.

When a leak has been detected and reported, the man in charge, usually a district foreman, either will have his assistant investigate the leak to determine the kind of repair necessary or make the investigation himself. When the foreman investigates the leak, which usually requires digging out in order to determine the nature of the leak and the kind of repair required, he should decide whether it can be repaired (1) under full pressure, (2) whether it should be repaired under reduced pressure, (3) or whether the line must be shut down completely.

Before the foreman decides whether or not to repair the leak under pressure, he should determine as nearly as possible whether the leak is from internal corrosion, external corrosion, sand holes, or split pipe. As the bottom of the line is more vulnerable to corrosion, either from inside or outside, than any other section of line, many leaks are found on the bottom of the pipe. Inasmuch as lap welded pipe was used in many of our older lines, and because little attention was paid to the position of the seam in the line, it becomes increasingly more important that the man in charge of repairs be able to determine whether the leak is in a seam. If it is in the seam, it will then be necessary to determine whether it is from internal corrosion, external corrosion, or a split in the pipe, before deciding whether repairs may be made safely under pressure. In the event the leak is in or near a coupling or sleeve, it is extremely important to determine how much pipe is still under the coupling or sleeve before attempting to do much work under pressure.

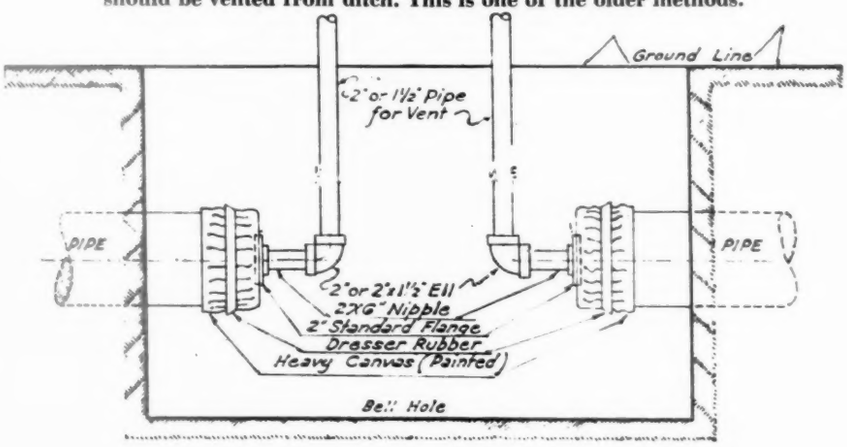
FIG. 2. New method of venting gas from ditch. This design gives a tighter connection than method in Fig. 1.

When there is doubt in the mind of the supervisor regarding whether the repairs may be made under full pressure, he should either call for reduced pressure or for a complete shutdown.

When the foreman has completed his examination, he should instruct a repair crew to assemble proper tools and equipment and to proceed to make the repairs. In addition to the necessary material and tools for making the repairs, the truck or pickup should be equipped with first aid kit, respirator, dry chemical fire extinguisher, an adequate supply of goggles, and spark resisting picks and hammers. In the event it is necessary to remove one or more joints of pipe, or a fitting, or to cut the line for any purpose, the repair crew will take along a grounding line with connections and pipe vents.

Because of the ever-present possibility of the pipe line serving as a conduc-

FIG. 1. When making a pipe or fitting replacement and the line must remain open for a considerable time, escaping gas should be vented from ditch. This is one of the older methods.



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tor for static electricity, stray currents from power lines, or soil current, resulting in a spark when the line is severed or reconnected, a bonding line should be securely fastened to the line on both sides of the proposed cut before the line is separated and reattached before reconnecting. This eliminates one source of ignition. (See Fig. 3.)

Also in the event of pipe replacement or fitting replacement, when the line must remain open for some interval of time for the purpose of cleaning up or enlarging the ditch or bell hole, it is important that the gas escaping from either end of the pipe be vented from the ditch or bell hole so that it may be dissipated to the atmosphere and thus eliminate the hazard of a fire or explosion while the ditch is being cleaned or other necessary work done before replacing pipe or fitting. These vents do not completely eliminate the hazard from fire and explosion, but they unquestionably reduce considerably the time of exposure. These vents were originally made of a square of canvas, treated with oil to render more gas tight, in the center of which was attached a 2-in. standard flange. The canvas was placed over the end of pipe and held in place with a gasket. A 2-in. street ell was screwed into the 2-in. flange and a joint of 2-in. pipe was made up to the street ell and extended over the top of the ditch or bell hole. (See Fig. 1).

The latest type of vent, which is far superior to the original design, is made as follows: A plate or head is welded onto the end of one-half of a center ring, a 2-in. nipple, threaded on one end, is welded onto the center of this plate and a hole tapped or drilled through the plate. Two lugs are welded onto the plate opposite each other and drilled for a Dresser bolt. Connection is then made to the end of the pipe joint with a follower and gasket on the other end with two Dresser bolts and nuts to complete the connection. To the outlet of this is attached an ell and a joint of 1 or 2-in. pipe that extends over the top of the ditch or bell hole. The end of the vent must not be closed.

This design permits a tighter connection and thus forces all escaping gas out through the vent pipe. Furthermore, it is indestructible. The only disadvantage is that one set of vents must be made for each size pipe in each district. (See Fig. 2).

It is also very important to have all men who are to work in and around escaping gas to remove all matches, cigarette lighters, and welder's torch lighters from their clothing and leave them on the truck before going on the job. Instances are known where gas has been ignited from matches in pockets of workmen becoming ignited from friction and one instance is known where an employe was burned fatally as a result of the gas being ignited from a welder's torch lighter attached to an employe's belt. Furthermore, a man who is a habitual smoker might unconsciously strike a match to light a cigarette. Men should also be instructed to refrain from lighting a cigarette and from going near a fire until their clothing is free from gas. Heavy woolen clothing appears to hold gas longer than cotton garments. Two accidents have occurred on our system as a result of gas in clothing becoming ignited when the wearer attempted to light a cigarette.

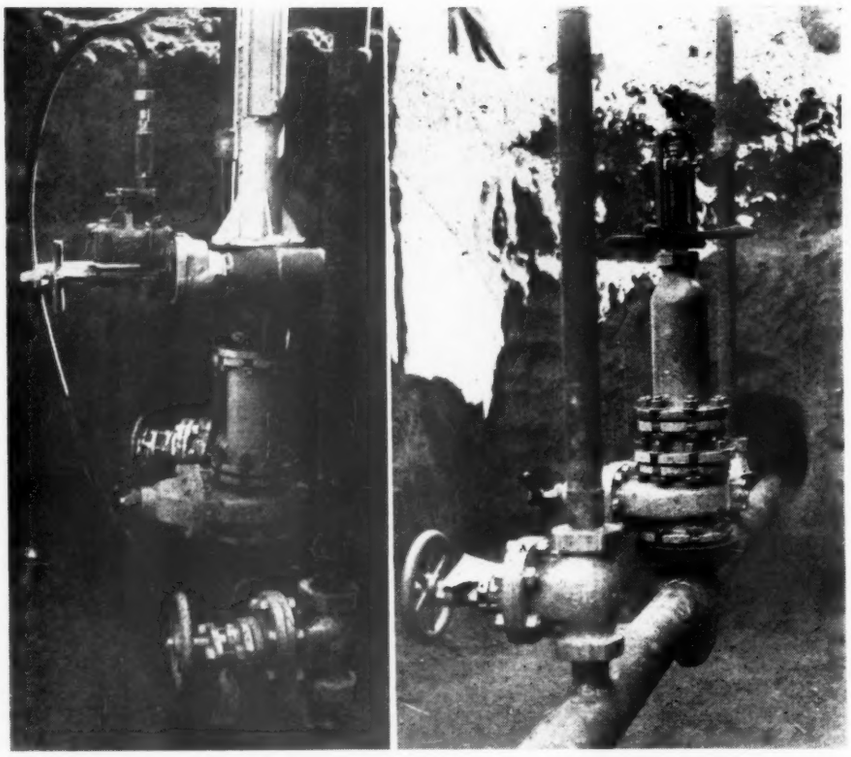
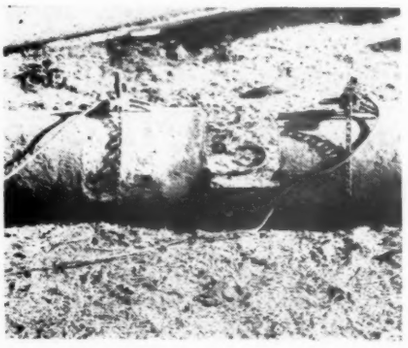


FIG. 4. High pressure tapping machine for tapping line under pressure. At left the tap is being made; at right tapping has been completed and plug inserted.

When welding and cutting is necessary in maintenance of gas pipe lines, a dry chemical extinguisher should be on hand and at least one person detailed to man one of these extinguishers so that in the event gas becomes ignited the welder may have a greater degree of protection from the fire. Either the dry chemical or carbon dioxide fire extinguisher may be safely turned on a man who is on fire. Insofar as possible, welding and cutting operations should be done a safe distance from escaping gas.

FIG. 3. Before a pipe is cut a bonding line should be fastened to both sides of the proposed cut to prevent an electrical spark that might ignite the gas.



Cars and trucks not needed in the immediate vicinity of where repairs are being made should be parked some distance away.

In addition to the fire and explosion hazards in repairing high pressure leaks, there is also the hazard of pipe failure. When a high pressure line opens up, the result is similar to that of a boiler explosion. Many lives have been lost in this manner. Hence great care and judgment must be exercised in determining whether a line should be worked on under pressure. Lines being repaired under pressure should be subjected to a minimum of shock and vibration. When any doubt whatsoever exists of whether it is safe to make the repairs under pressure, the line should be shut down. When a chance is taken and the line fails, the period of shutdown is usually longer than a prepared shutdown would be and human life can never be replaced.

Accidents also have occurred as a result of removing a saddle or leak clamp that previously had been installed on a high pressure line. These accidents apparently were due to the pipe wall having been weakened by the pressure applied in closing off the leak. Some pipe line men, in order to prevent a pipe failure when removing an old clamp, install a clamp on each side of the clamp to be removed and tighten sufficiently to reinforce the pipe while the old clamp is removed and replaced. At any rate it would be well, before removing an old clamp under pressure, for the man in charge to satisfy himself that the pipe has not been damaged or weakened by the clamp. Where a sleeve, saddle, or a clamp has been installed on a split joint,

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it should *not*, under any circumstances, be removed under pressure.

There is also the hazard of foreign particles getting into the eyes and the inhalation of such particles into the respiratory organs while working on high pressure leaks. It is therefore imperative that goggles and respirators be regular components of each repair crew's equipment.

In some instances when working in deep pits or bell holes, it may be desirable for the men in the bell hole or pit to wear fresh air hose masks in order to be able to work indefinitely in atmospheres deficient in oxygen.

One of the most important developments in gas pipe line maintenance, and especially in maintenance of city and town tap lines, is the high pressure tapping machine. Shutting off the gas to a distribution plant is one condition all gas men endeavor to avoid, not only because of the adverse effect that such a shutoff has on a company's reputation for continuity of service, and the extra work necessary to reinstate gas service, but also because of the hazards to employes and customers involved in each shutdown.

When a bad leak develops in a line that cannot readily be shut down, or when a bad joint of pipe needs replacing in a line or river or creek crossing, it may be done in short order and the consumers will never know anything about it. Assume that we have some bad pipe in a river crossing of a tap line to a large town. It is mid-winter and the town should be shut off only as a last resort. A bypass is laid across the river. A special fitting is electrically welded on the line. This fitting forms the body of a stop cock or valve. Two nipples are then electrically welded onto the line, one in each side of the fitting already welded on the line. A gate valve is connected to each of the two nipples and holes are drilled in the line, working through the open gate, after which the gates are closed. The tapping machine is then bolted onto the flange of the stop cock case already mentioned and a hole drilled through the top and bottom of the pipe. The two pieces that have been cut out are removed and a plug inserted. This operation finished, the equipment is moved by road to the other side of the river, where the same fittings and connections are made. The bypass line is then connected and gas turned on through the bypass line. The two gate valves between the plugs and the river are used as blowoffs to drain down the river crossing, which may then be repaired and placed back in use without the slightest interruption in service and, not the least important, without the extra work and without the hazards attendant to such shutdowns. (Fig. 4).

Science and engineering may make still further improvements in the safety and efficiency of gas pipe line maintenance, but technological developments will not eliminate the continued need for skill and judgment in this particular phase of the natural gas industry.

★ ★ ★

Government pipe lines

In the disposal of the Government's oil-carrying pipe lines, "first preference will be given to continuing the Big and Little Inch in petroleum service," under the Surplus Property Administration's proposed disposal policy.

Highlights of the proposed disposal plan are:

1. If the Big Inch and Little Big Inch cannot be disposed of for the movement of crude oil and petroleum products from the southwest to the east seaboard, they should be disposed of for service to interior points.
2. Disposal to private interests will be given preference.
3. All segments of the petroleum industry, particularly small independent operators, will be given the opportunity of acquiring the lines.
4. Should it prove impossible to sell the lines to the petroleum industry, consideration will be given to the possibilities of lease.
5. Public operation on a full cost basis may have to be considered if all efforts to dispose of the lines to private industry should fail.
6. Disposal for conversion to natural gas will be favored only if it proves impossible to keep the lines in petroleum service and the national security is otherwise adequately protected.

These were the chief recommendations in the report submitted by W. Stuart Symington, administrator.

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OIL, GAS AND GASOLINE PIPE LINE CONSTRUCTION

Pipe Line

P 670.

PIPE LINE METERING

By **W. H. MARSH,** *Chief Engineer, Gasoline and Oil Meter Division*

Rockwell Manufacturing Company

EXCLUSIVE

With the rapid development of pipe line systems for transportation purposes in recent years, the need for more efficient and flexible methods of measurement has manifested itself. Measurement by tank gages becomes almost an impossibility when a variety of products are being handled simultaneously in different sections of a system, particularly when inter-company exchanges and transfers are involved.

For quite a number of years orifice or venturi meters had been used, mainly to establish rates of pumping and to determine operational difficulties. Although this type of instrument was quite satisfactory for the purpose intended, it was not acceptable for determination of true volume throughput, due to inaccuracy in registration under conditions of varying rate of flow, viscosity, etc.

Considerable work was done toward developing the turbine or velocity type meter for measurement of crude oil but these types also proved unsatisfactory for the same reasons as were true in the case of orifice and venturi meters.

In the early thirties under the sponsorship of the ASME, a series of tests was conducted on various types and makes of meters at the University of Oklahoma. These tests provided very valuable information regarding what reasonably could be expected in the way of accuracy, life, and other characteristics inherent in the variety of designs tested.

It becomes evident that in order to attain the accuracy of measurement required under the wide variety of operating conditions existing, a meter of the volumetric or positive displacement type would be required. The approach to this problem by different designers resulted in the production of 3 basic types of positive meters, all of which are modifications of designs heretofore used in handling liquids at lower rates and generally on intermittent duty. In order of their introduction to this service these meters may be classified as follows:

1. Sealed piston meter—leather, composition, or metal ring seal between piston and cylinder; valve-driven by crankshaft.
2. Clearance type piston meter—depends on precision fit between piston and cylinder; valve action produced by piston movement in relation to ports in cylinder.
3. Rotary meter—controlled vane.

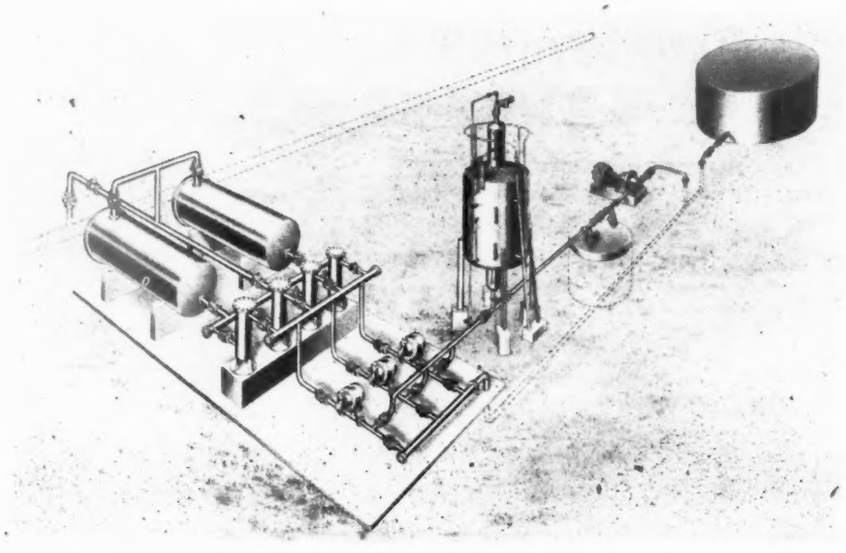
Regardless of the type of meter used, it is absolutely essential that it be protected by the installation of efficient filters, strainers, or precipitators to remove not only large particles of foreign material, such as are commonly present in a crude oil stream, but in the case of finished product lines every attempt should be made to take out the fine abrasives that generally are present. These abrasives are more injurious to the meter than the larger particles as they tend to deposit on the meter bearing surfaces and act as a lapping agent. From a standpoint of obtaining maximum meter life it is desirable to provide cleaning equipment that will remove particles down to 40-50 microns. This requirement applies only to finished product lines as the fine abrasive present in crude tends to carry through with the stream and the crude also has a certain amount of lubricating value.

To obtain greatest accuracy it is necessary to provide calibrating or proving facilities that are of sufficient capacity to reduce observation errors to a minimum. Frequent calibrations should be made to insure that all metering equipment, including accessories, is in good mechanical condition. On finished product lines it is advisable to run a calibration on each tender change as the meter registration factor is affected slightly by relatively small variations in the characteristics of the product flowing.

Temperature variations may be taken care of in a number of different ways. In some cases where it has been determined by experience that only very small temperature variations occur, and/or where the changes take place slowly, it is probably necessary to take only periodical line temperature readings for purposes of correcting meter readings. When it is impractical to make frequent observations a recording thermometer should be provided. At points where rapid and frequent temperature changes are likely to occur, automatic temperature correcting devices are available. Automatic compensation is normally provided for operation over a range of 100°F. and is designed to handle a sufficiently wide range of API gravities to take care of all normal requirements met in pipe line operation.

In view of the number of pipe line systems that have been linked together and the complex nature of the operations in which they have become involved, the Joint API-ASME Committee on Volumeter Research 2 years ago assigned the task of developing a "Manual of Recommended Practice" covering the installation, calibration, and maintenance of positive displacement liquid meters. This manual should be available shortly and, inasmuch as its recommendations are based on the experience and results attained in actual practice, covering a wide variety of operating conditions, it should prove to be a valuable guide in attaining a high degree of accuracy in measurement with a minimum of maintenance. ★ ★ ★

Typical pipe line take-off meter installation.



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CONSTRUCTION OF 3200-FT. NATURAL GAS PIPE LINE SUSPENSION BRIDGE OVER RED RIVER

By **GORDON R. LUNT,** *Manager, Bridge Department*
Pittsburgh-Des Moines Steel Company

EXCLUSIVE

To cross the treacherous Red River near Williams, Louisiana, with its 24-in. pipe line from the Carthage, Texas, gas field to Sterlington, Louisiana, United Gas Pipe Line Company selected a pipe line suspension bridge.

The engineering firm of Matthews and Kenan, San Antonio, Texas, was employed to design the structure. Pittsburgh-Des Moines Steel Company was awarded the contract for the construction.

On July 5, 1945, the Federal Power Commission issued an order to United Gas Pipe Line Company authorizing the project. Immediately the contractor began moving in equipment and workmen. Building of gravel-surfaced construction roads from the adjacent improved highways to the bridge site was begun, to permit the movement of materials, equipment, and workmen to and from the site under all weather conditions. One and one-fourth miles of road were built on the east side and one mile on the west side of the river.

Actual construction of the suspension bridge began August 1, and the pipe on the bridge was tied into the line on November 25, a total of 117 calendar days and 103 work days.

The bridge has a length, face-to-face of anchorages, of 3990.31 ft., a main span of 1600 ft. with two side spans of 800 ft. each, making a total loaded length of 3200 ft. It is designed for a future 24-in. line.

Each main anchorage is composed of a rectangular concrete block 57 ft. 3 in. long, 22 ft. 3 in. wide, and 19 ft. 6 in. deep at the back and 16 ft. deep at the front. The top at the transverse center line is approximately 5 ft. above the normal ground line. Of the total depth of concrete, 14 ft. 6 in. is within a permanent cofferdam that is constructed of steel sheet piling approximately 40 ft. long driven down approximately 25 ft. 6 in. below the elevation of the bottom of the concrete of the anchorage, which is also the depth of excavation within the cofferdam.

That part of the cofferdam within which the concrete is in contact with the steel sheet piling is braced with steel wales that are electrically welded to the steel sheet piling. One hooked reinforcing rod also was welded to each steel piling approximately 6 ft. 9 in. below the top.

When the concrete was poured the steel wales and hooked rods became imbedded in the concrete, making a structural unit of the steel sheet piling cofferdam and the concrete. Within the concrete of the anchorages are also imbedded the steel anchorage bolts for the main and wind cables.

Due to the large quantity of concrete in each anchorage and the shortage of labor for continuous pouring operations, each anchorage was designed with a vertical keyed construction joint at the transverse centerline so that each anchorage could be poured in two pours.

Each sub-pier of the two main piers consists of two steel caissons, each 13 ft. O.D., 45 ft. long on the west pier and 50 ft. long on the east pier. These caissons were carried to grade using the open dredging method and by loading with a 275-ton load box filled with sand dredged from the caissons.

After the caissons were sunk to grade, twenty 10-in. steel H-pile were driven to refusal in each caisson using a No. 1 Vulcan steam hammer. A seal course 8 ft. deep was then poured in each caisson. After the seal course had set sufficiently, the caissons were dewatered and filled with concrete to within 10 ft. of their top.

The 10 ft. of caisson top course with connecting strut between the two caissons was poured monolithically and the 18-ft. pier tops were poured next.

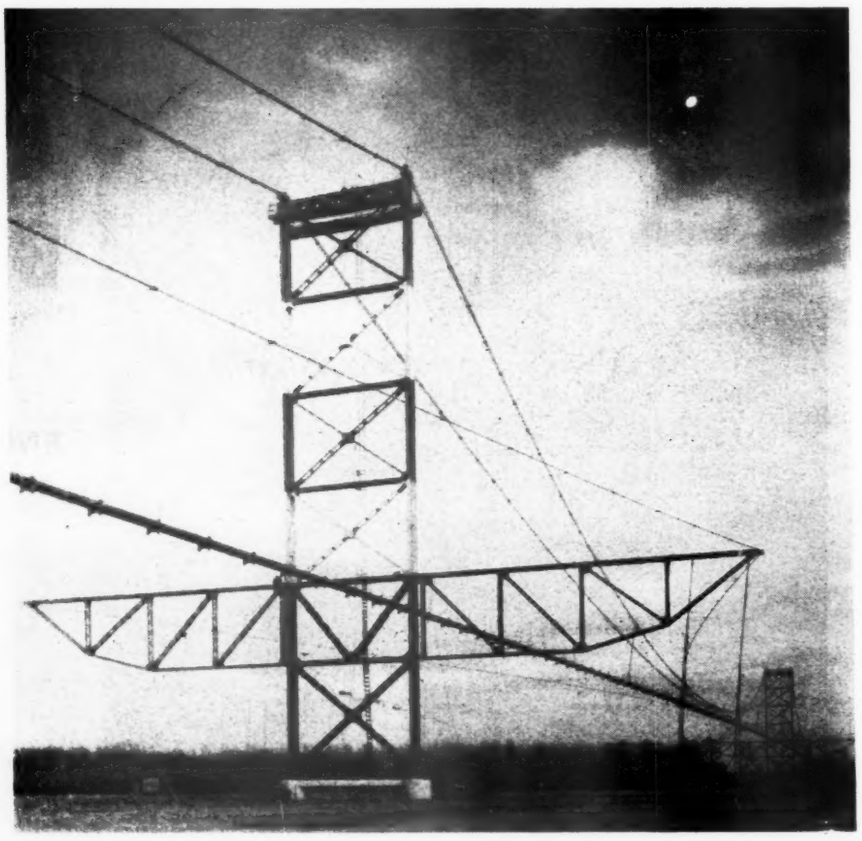
Each rest pier consists of two concrete bases 9 ft. square and 8 ft. deep with connecting strut and two independent pier tops. Each pier base is founded on 8 steel H-pile driven to refusal with a 5000-lb. drop hammer.

Each main tower rises 163 ft. above the pier top elevation to the center of the main cables.

The columns are spaced 36 ft. center-to-center and the pin-connected wind trusses have a total horizontal spread of 215 ft. center-to-center of wind cables.

Each rest tower has a height of 66 ft.

Two main towers in United Gas Pipe Line suspension bridge.



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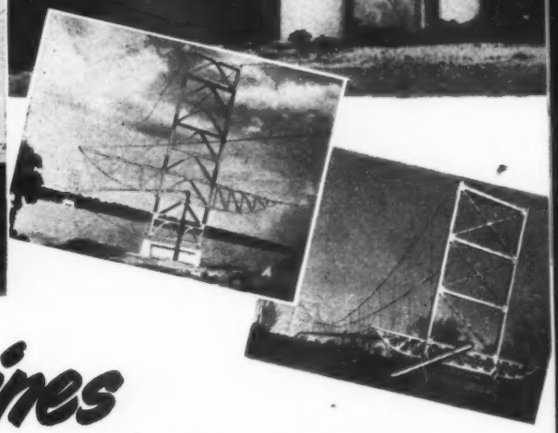

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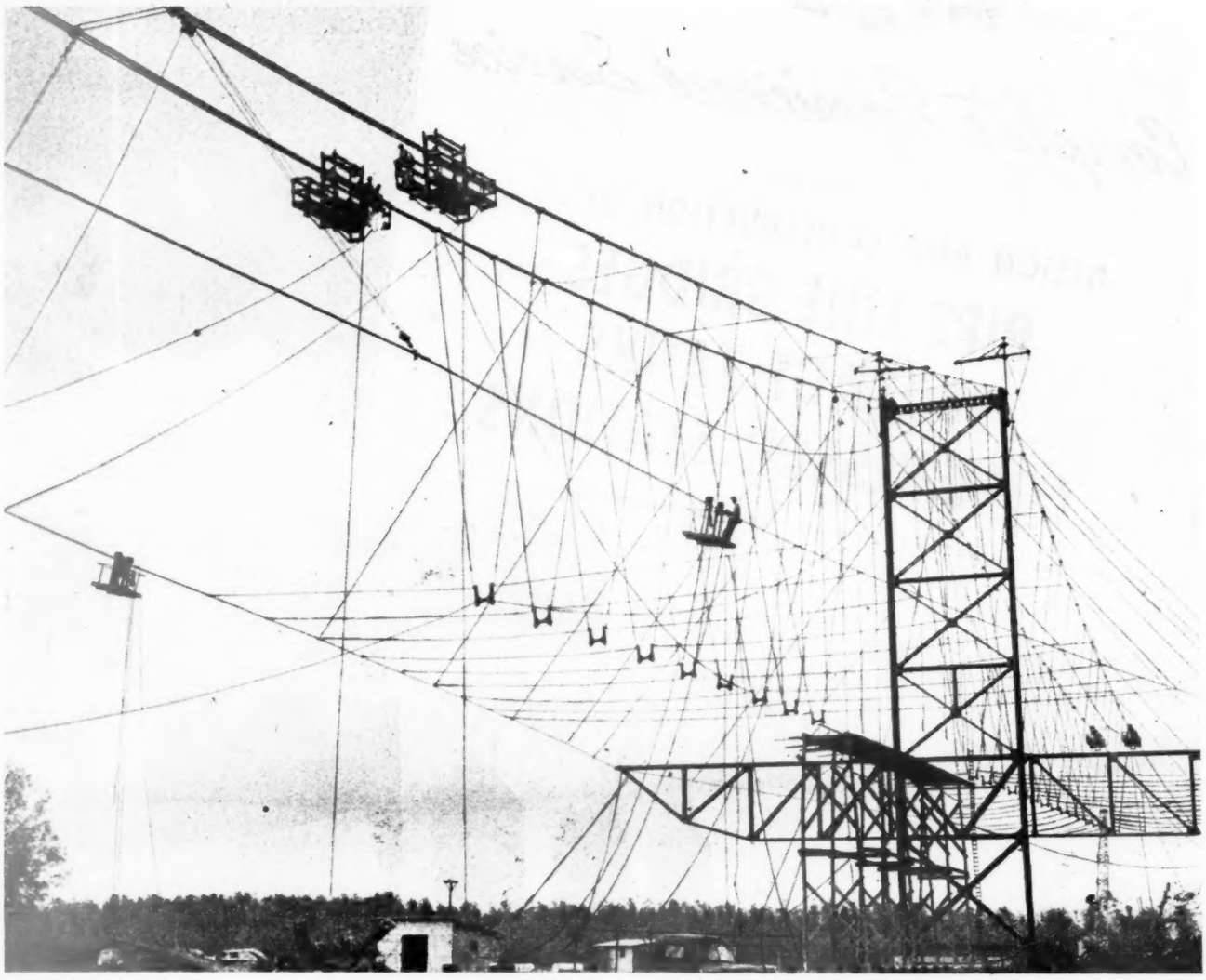
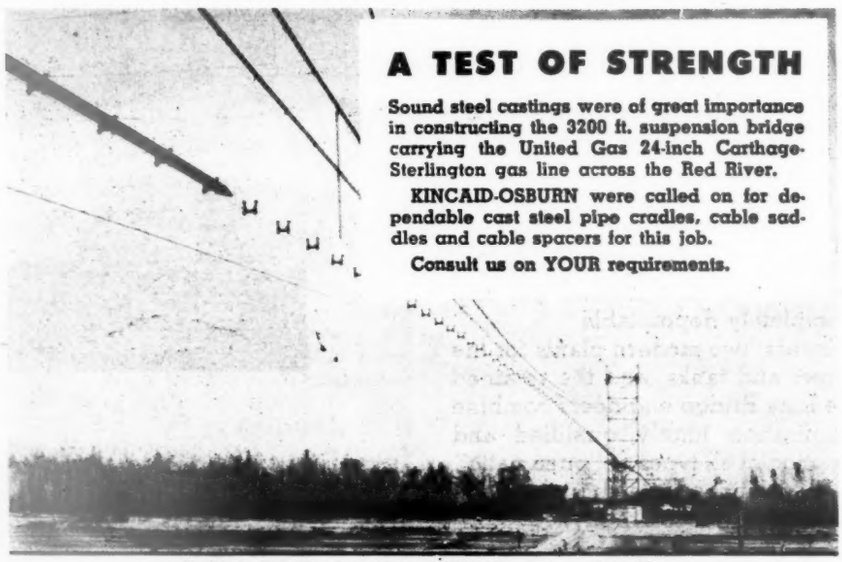


Erection of the suspenders, cable clamps, and pipe cradles. Special travelers, some of which are shown, were used in this work, as well as for spacing the wind cables.



A TEST OF STRENGTH

Sound steel castings were of great importance in constructing the 3200 ft. suspension bridge carrying the United Gas 24-inch Carthage-Sterlington gas line across the Red River.

KINCAID-OSBURN were called on for dependable cast steel pipe cradles, cable saddles and cable spacers for this job.

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from the top of the piers to the center of the main cables and a spread of 26 ft. center-to-center of columns at the base and 6 ft. at the top.

Each main cable consists of three 2⅝-in. diam. galvanized steel bridge cables each 4029 ft. 4⅝ in. long face-to-face of sockets. Each wind cable consists of one 2¾-in. diam. galvanized steel bridge cable 4023 ft. 3½ in. long face-to-face of sockets. All suspenders and hand lines are galvanized Siemens-Martin strand.

Each galvanized main cable clamp consists of two 5-in. by 5-in. by ½-in. angles. These are 1 ft. 4⅜ in. long and are welded together to form the bottom part of the clamp. One 10-in. by ⅝-in. by 1-ft. 4⅜-in. plate forms the top part of the clamp. Two exterior and two interior cast-steel cable spacers hold the three 2⅝-in. main cables on 4⅝-in. centers. The top plate, spacers, and bottom part are bolted together with sixteen ¾-in. diam. machine bolts.

Each main cable with reel weighs ap-

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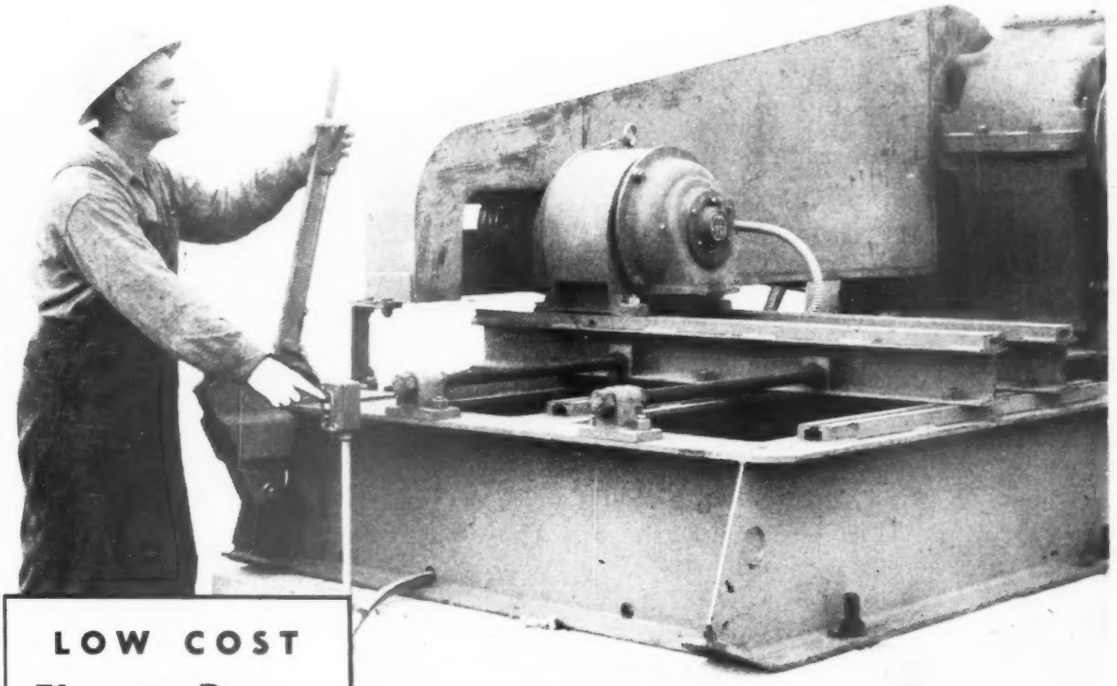

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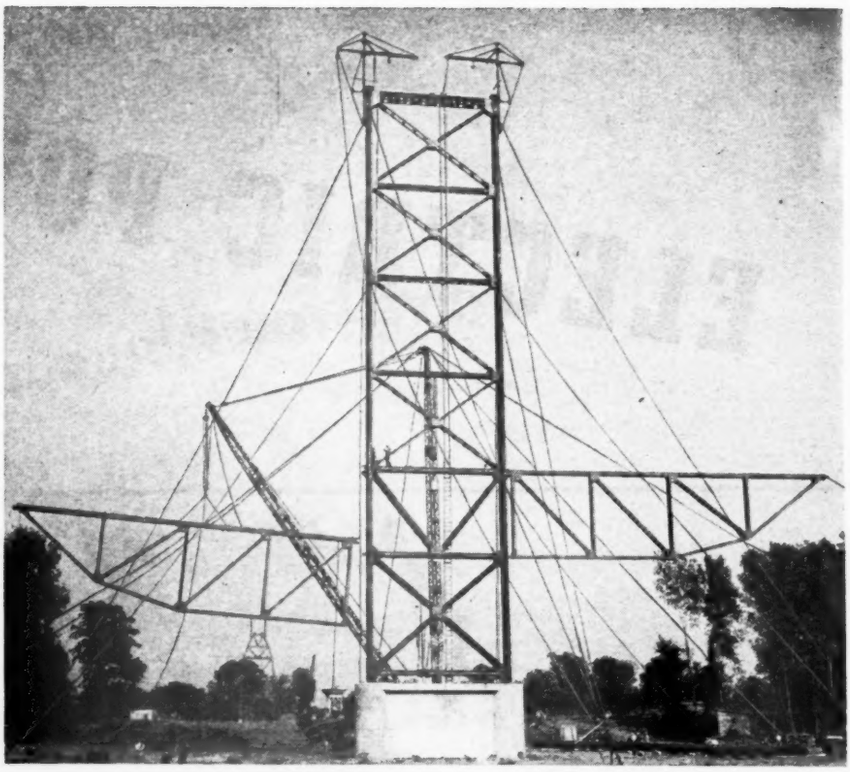
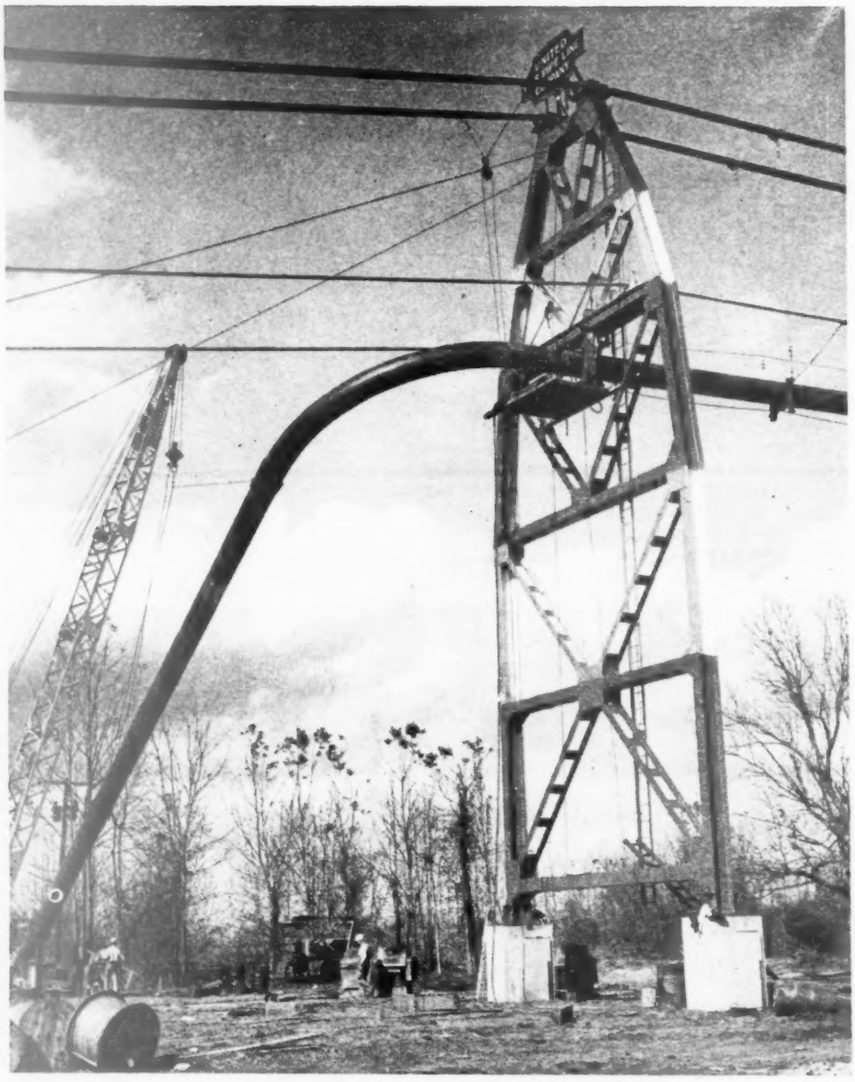
proximately 26 tons, and each wind cable with reel has a weight of approximately 28 tons.

Due to the extreme lengths, as well as weights, of the cables, special erection methods had to be devised. Each cable was pulled over specially constructed rollers equipped with roller bearings. The main cables were lifted from the rollers and placed in the cable saddles by use of special hammer-head derricks mounted on the columns of the main towers and cable erection jibs mounted on the rest towers.

After each main cable had been adjusted at the anchorages to obtain the proper "no load sag," and the wind cables had been placed in their saddles at the end of the cantilever wind trusses and tied up at several points to the main cables, 8 special travelers were erected. Four of these travelers ran on the main cables and automatically spaced the cables as the travelers were moved forward. They were also used for erecting the main cable clamps, suspenders, and pipe cradles. The 4 remaining travelers ran on the wind cables and were used in erecting the wind cable clamps and suspenders.



The rest tower.



Erection of wind cantilever truss. Note hammer-head derrick at top of tower.

When possible, all suspenders and pipe cradles were placed on the ground directly below their final erected position in the bridge. In order to erect the cradles and suspenders on that section spanning the water, however, it was necessary to use a specially constructed work barge to transport material, equipment, and men to the proper locations.

Upon completion of the cable erection, the 24-in. diam. pipe was erected by placing 3 joints of pipe, which previously had been welded together on the ground, cleaned and given a primer coat of paint, on welding platforms constructed to the proper elevation adjacent to each main pier.

Position welds were made at each joint welded on the platforms, then the pipe was shoved out on the main span and each side span by pushing two ways from each welding platform. The final welds were made at the center of the main span, adjacent to each main tower and at each end of the structure.

All pipe welds were tested by the Precision Inspection Service, Houston, Texas. A Magnaflux test was made during the making of a weld. Upon completion of the weld it was radiographed.

After the pipe on the structure had been tied into the main line at each end of the bridge, it was tested with natural gas at a pressure of 950 lb. per sq. in.

Due to the short time allotted to construct this bridge, it was necessary to use two derrick outfits, one crane, one bulldozer, two winch trucks, and one concrete plant on each side of the river.

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Six main cables and two wind cables before installing.

All concrete materials were dry batched and trucked to the mixers, which were set conveniently for pouring at the anchorages and piers.

The rapid completion of this large and important structure was made possible only by procuring directives on all cables and structural shapes that the contracting company did not have in stock at its fabricating plant. The wholehearted cooperation received from the owners, designing engineers, field engineers, construction supervisors, fabricating shop, cable manufacturer, as well as other material suppliers, contributed materially to the completion of the project. Deliveries of fabricated steel, cables, and castings were so well timed that the progress of the job was never delayed.

Structural steel was fabricated at the contractor's plant in Des Moines, Iowa. Cables were supplied by John A. Roebling's Sons Company, Trenton, New Jersey. Cast-steel pipe cradles, cable saddles, and cable spacers were supplied by Kincaid-Osborn Electric Steel Company, San Antonio, Texas.

The construction of the bridge was under the direction of the writer of this article, with A. C. Van Tassel as project manager. The owners were represented by D. R. Pflug, supervising engineer, and Carroll Smith, engineer. Robert S. Cooper, of E. M. Freeman and Associates, Shreveport, Louisiana, and L. D. Myers, of United Gas Pipe Line Company, were resident engineers on the work. ★ ★ ★

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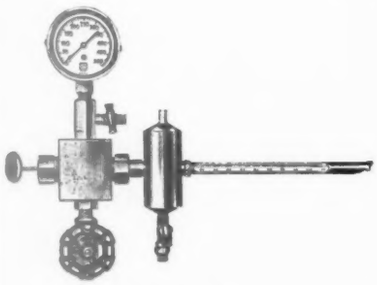

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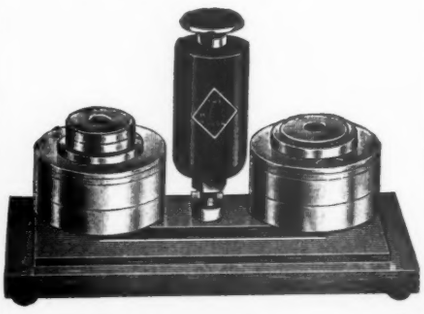

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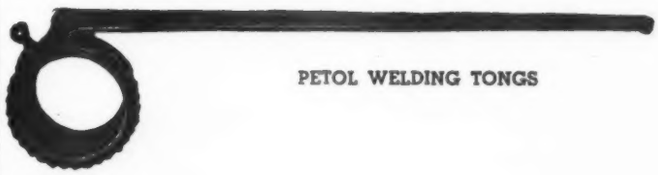

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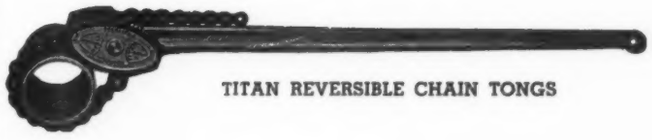

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ELECTRONIC PIPE LOCATORS, LEAK DETECTORS

By **HARRY A. FORE,** *President,* Goldak Company

● **Early locators.** In the early type of pipe locator, the pipe or cable was energized by connection to a buzzer or induction coil, and traced by a pick-up loop antenna. This type, as well as an adaptation of the so-called treasure finder, is still used.

EXCLUSIVE

The modern type of utility instrument about which this article is written, operates entirely above the ground without any connection to the pipe, except for one special application. They have been developed as the result of field use of thousands of instruments over a period of 10 years and embody what appears to be the optimum choice of circuits, tubes, and principle of operation.

● **Pipe survey.** The electronic pipe locator does not and cannot operate like a "metal detector" except in general principle. To understand this, we must consider how it functions.

To survey pipes, they must be energized and this is done by suitable electromagnetic radiation from an oscillating loop antenna. If such an energizer is set on the ground it induces circulating currents in the earth.

● **Earth-pipe system.** An extended pipe embedded in the energized earth will act as the locus of the return currents and the field envelope radiated by the pipe can be followed by a sensitive detector-amplifier employing a loop antenna.

● **Ground conditions.** It is apparent that the operation depends just as much on the earth associated with the pipe as it does on the pipe itself. If the earth is highly conductive as the result of minerals and moisture, the circulating currents are limited to a small area close to the energizer and the pipe can be worked only for a short distance.

The other extreme condition is that of a pipe embedded in dry neutral earth such as gravel. In this case the induced currents are feeble and the return current in the pipe does not set up satisfactorily strong radiation.

Fortunately such extreme conditions are seldom encountered. The usual condition is that of moderate conductivity of the soil, which results in satisfactory energizing of the earth-pipe system. By certain simple manipulations of the detector unit, the pipe can be located, traced, centered, and the depth measured to a close approximation.

● **Direction finder principle.** The electromagnetic field radiated from an energized pipe (or underground cable) has a cylindrical envelope. A detector antenna picks up a maximum signal when it is in such position that its plane is perpendicular to this envelope. Thus, when the antenna is vertically above the pipe the signal is a maximum, and if the characteristic of the field and the amplifier are suitable, the received signal rises rapidly to a sharp and clearly defined maximum, this indicating the location of the pipe within a narrow space.

● **Pipe separation.** A sharp, well defined maximum signal is not only necessary for accurate spotting of a pipe but obviously is essential for separating closely spaced parallel pipes. One requirement is a special type of detector-amplifier to produce a sharply defined signal but a further requirement is the use of the "induction" field of the oscillator instead of the "radio" field. The inductive field, varying in intensity inversely with the cube of the distance, will effect sharp localizing of the pipe whereas the "radio" field cannot do so. An electronic locator therefore, using the radio field will give a very flat response characteristic over the pipe making accurate localizing impossible; it is correspondingly ineffective for separating closely spaced pipes.

The instruments illustrated use a degree of inductive field determined to be optimum as the result of several years of laboratory and field experience. Localization and separation of pipes is gratifyingly positive.

● **Sharp centering.** Although spotting of a pipe can be done positively within a space of a few inches using the positive signal, the use of a null signal gives the position of the pipe within a space less than the diameter of the pipe. This is accomplished by turning the receiver antenna through 90 deg., bringing it tangent to the cylindrical field from the pipe. When the null signal position is found, the center axis of the pipe is directly below the center line of the antenna. The proper use of the induction field and a sharp "trigger" action in the amplifier insure accuracy.

High gain amplifier, left, with filter to eliminate traffic and undesired vibrations. Leak located by sound and measurement through mechanical contact between pipe and vibration pick-up. Pipe locator, below, mounted on handles and operated as in induction balance for locating pipes.

EVER MEET A MAP EDITOR ?

The three men in the picture are *editors* — not of a magazine or newspaper or book — but of maps. These photogrammetrists are editing the final details on a base line map before reproduction

The map they are checking was constructed by Multiplex methods from a scientifically controlled Jack Ammann aerial survey. This base line map incorporates such information as property owners, roads, rivers, creeks, woodlands, etc. It has been correlated with the legal, recorded field note descriptions and actual occupation established through the visible evidence of the aerial survey, and verified by our field investigation

Oil and pipe line companies, municipalities and many departments of our own government know that they can depend on the accuracy and precision of aerial surveys and maps produced by Jack Ammann Photogrammetric Engineers. Maps by the Jack Ammann organization will save you money on your operations. We are prepared to meet your needs anywhere. Consult us.

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REGIONAL AND FEE MAPS

REPRODUCTIONS

Pipe locator, above, used for tracing lines, or for spotting approximately known pipes. Below, centering is done accurately, within a space narrower than the diameter of the pipe.

● **Depth measurement.** If the receiver antenna is held at an angle of 45 deg., and off to one side of the energized pipe and its plane parallel to it, another null will register when it is tangent to the envelope. This gives a right-angle triangle with two 45 deg. angles and thus the distance between the near edge of the receiver antenna and the vertical portion of the pipe is equal to the depth. A device built into the detector unit facilitates this operation without the use of any external accessories.

● **Accuracy of depth measurement.** As the speed of propagation of the radiation is different in earth and air, an error is introduced in depth measurement due to refraction. The effect is to make the apparent depth less than the real depth by an amount varying with the index of refraction. The error due to refraction is seldom more than 10 per cent.

Another error arises from the disturbing radiation from an adjacent pipe, but a simple manipulation of the oscillator-energizer can eliminate this error.

● **Additional uses.** It follows from the above discussions that other aspects of pipe survey are possible. For example, the location of stubs and services can be determined, thus making possible the location of tees and ells. Dead ends can be spotted, and any illegal connections to a main can be found readily.

● **Non-metallic pipes.** Although nonmetallic lines cannot be energized in the usual manner, a provision is made by which they can be worked. The oscillator unit is provided with a special shielded energizer whereby a metallic tape inserted in a terra cotta pipe, for example, can be energized by direct connection. Thus the line can be followed and worked the same as if the pipe itself were metallic.

This provision also permits the localizing of a particular pipe from two or more closely spaced pipes. The success of such separation is further insured by the use of the correct value of the induction field and a suitable "trigger" action in the detector. A conventional "radio" type locator is of comparatively little value in special work of this kind.

● **Induction balance.** In all the above operations, the two units, energizer and detector, are used essentially as a direction finder. This application is satisfactory when the approximate location and general direction of the pipe are known. When the location of the pipe is not known approximately another procedure is followed, the units being mounted on a pair of handles and used as an induction balance.

When so arranged, the oscillator antenna is adjusted by a microtuner control to a null position with respect to the receiver and the apparatus is carried over the ground. Whenever carried across a pipe or cable a sharp signal is given in both the head phones and on the meter.

This method constitutes a powerful means of locating deeply buried pipes. It is also very useful in locating short stubs and illegal connections.

● **Valves.** One of the most useful applications of the induction balance is in the location of gates and valves. To insure the detection of such difficult objects the instrument is best operated on extension handles, close to the ground and carried directly above the line and parallel to it. A positive signal is obtained when the receiver unit is directly above the valve.

● **Ditching machine.** Another important use of the balance is surveying ahead of a ditching machine. By this means every pipe or cable crossing the course of the trench can be spotted definitely and its location marked. The operator of the ditching machine can then cut to within a safe distance of the cross pipe and avoid a dangerous or costly accident.

● **Valves and "Buffalo" boxes.** Although the regular pipe locator, operated on handles as an induction balance, is quite effective for locating bunched metallic objects such as valves, a special locator operating on a different principle, is better adapted for the purpose.

This device is capable of locating surprisingly small metallic objects, and is provided with a wide range of compensation to offset the adverse effects of unfavorable ground conditions.

● **Electronic leak detectors—theory.** As is well known, the vibrations set up by a fluid escaping from an irregular orifice travel considerable distance along the connecting pipes and a suitable listening device in contact with the pipe can reveal the existence of the leak.

By measuring the intensity of the sound at 2 or more points along the pipe, the location of the leak can be determined with a fair degree of accuracy.

● **Requirements.** To accomplish detection and location the apparatus should embody certain features. The instrument case should constitute an effective shield against extraneous electric fields.

The apparatus should be light in weight, entirely self-contained, and de-

After centering, a simple manipulation gives the depth of the pipe directly without calculation, by aid of the built-in depth device.

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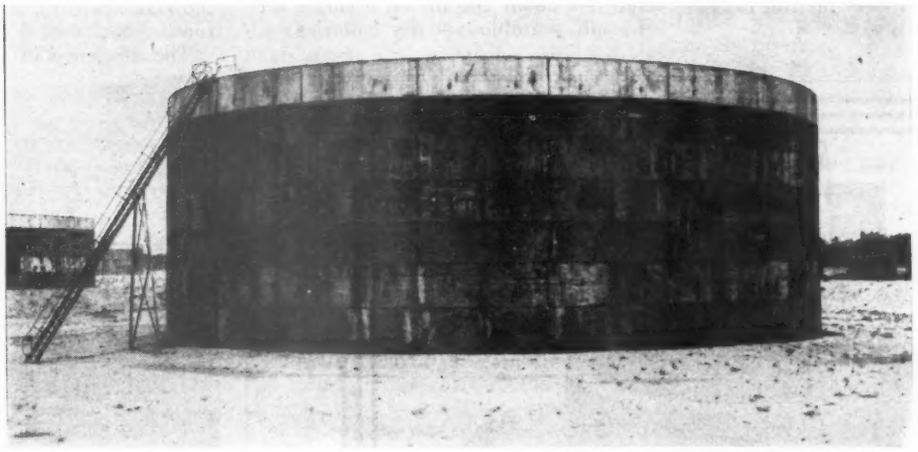

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signed with the fewest and simplest possible controls.

The vibration pick-up (microphone) and the head phones should be responsive to the whole range of leak vibration frequencies from 1500 to 10,000 cycles.

The meter should be devised to give steady readings under conditions of rapidly varying extraneous noises.

The meter action should be controllable over a wide range to permit non-leak sounds from obscuring the measurement of the leak sounds.

The amplifier should have a straight line characteristic over the leak frequency range and the "gain" should be fully controllable to meet the full range of leak sound intensity.

Finally, a suitable filter should be provided so the operator can eliminate the sound vibrations associated with non-leak sources such as foot and vehicular traffic, moving machinery, etc.

● **Apparatus.** The detector should employ suitable tubes of the low filament voltage type and which impose the minimum of B battery drain. The use of the common automobile type of tube necessitates the use of separate 6-volt storage battery that usually weighs twice as much as the detector itself. Dry battery operation of such a type of detector is prohibitive in cost.

A properly designed detector will operate for about 200 hr. on a single set of small, portable type dry batteries.

● **Operation.** The basic operating procedure is to make measurements of the sound intensity at several points along the pipe. On the assumption that the vibration intensity falls off uniformly along the line the approximate location of the leak can be calculated as follows:

"M" and "M" are meter readings at points 2 and 1, respectively. "D" is the distance between 1 and 2. "X" is the distance between the leak and point No. 1. Then "X" = "D" × M/M—M.

● **Application.** A high-grade leak detector of the above type is effective on leaks of various fluids dependent upon line pressure, viscosity, irregularity of the leak aperture, and size of the aperture.

The efficiency of the detector is favored by high pressure, low viscosity, and small, irregular apertures. The more streamlined the aperture of the leak, the less vibration it sets up and detection is correspondingly difficult.

Electronic valve and box locator. Operates through earth, pavement, snow, etc.

● **Location through pavement.** Under favorable conditions of pipe contact with the surrounding earth, the leak sound can be picked up by placing the microphone on the pavement; however, the most dependable method is to place the vibration pick-up in physical contact with the pipe. This can be done by making use of certain accessories. If the pipe is otherwise not accessible, it can be made so by placing a long rod down against it through a jackhammer hole in the pavement.

It will be realized from the above that an electronic leak detector is more properly described as a "leak listener"; that a large leak at low pressure may not be subject to detection for the same reason that one cannot hear a gentle wind blowing through an open door, but it whistles loudly through a crack.

A properly designed detector, however, will prove to be approximately 90 per cent efficient on the general run of leaks in water and high pressure fuel lines. ★★★

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MAGNESIUM FOR CATHODIC PROTECTION OF PIPE LINES

By **ROBERT M. HUTCHISON,** *Director of Research*
Houston Natural Gas Corporation

EXCLUSIVE

DURING World War II magnesium was used extensively in the manufacture of airplanes, and because of the great need for this weapon it is not likely that much thought was given to the other uses to which the metal might be put. Now that the war is over, however, if predictions are true, magnesium is destined to be used just as extensively for the protection of pipe lines and other metal structures against electrolytic corrosion. The following is quoted from an article by Porter Hart and Yale W. Titterington*:

"Because of its position in the electrochemical series it is an ideal source of current and, therefore, is very adaptable for cathodic installations. It has an electrochemical equivalent of 1000 ampere-hours per pound and a solution potential to a copper sulphate electrode of from 1.8 to 1.7 volts, depending upon whether commercially pure or alloyed material is used. Compared with zinc, which has an electrochemical equivalent of 372 ampere-hours per pound and a solution potential of approximately 1.1 volts, in terms of installation, it is estimated that one magnesium anode station would give the same current output as 3.8 zinc anode stations of similar size.

"Extensive research over a period of five or six years has indicated that magnesium anodes can be used for cathodic protection, that in connection therewith there was no evidence of polarization and that it was safe to assume that one pound of magnesium will have a current output of 500 ampere-hours.

"Laboratory investigations indicate that the life and efficiency of such an anode is largely dependent upon three factors, namely:

(1) Composition
(2) Backfill
(3) Current density.

"The effect of composition is that the percentage of iron, nickel, and copper above a definite maximum tends to accelerate the local cell corrosion of the anode.

"The selection of a backfill material is particularly important in that herein lies the greatest opportunity of reducing local cell corrosion of the anode surface. One specific example of the effect of the electrolyte on the performance of magnesium anodes is that chromates in the absence of chlorides given excessive polarization and seriously restrict the current output.

"Current efficiency increases with current density up to some maximum value, primarily because the percentage of local corrosion to useful current decreases. At a current density of 200 milliamperes per square foot, the current efficiency will be approximately 50 per cent."

As a result of the experimentation of Hart, Titterington, and others over a period of 5 or 6 years many companies became interested in the use of magnesium for cathodic protection, and when the Houston Natural Gas Corporation, early in 1945, began the construction of a 43-mile 8 and 12-in. gas transmission line from Corpus Christi to Alice, Texas, it was decided to apply this type of protection to it.

The pipe line in question had been well coated and wrapped prior to laying and during construction it was given a very close holiday inspection with the newest type holiday detector.

Therefore, when the calculations were made to determine the magnesium requirements, an assumption was made that the coating contained not more than 1 per cent voids. This assumption, together with an estimated current output of 90 milliamperes per magnesium anode at 50 per cent efficiency, indicated that full protection for a period of 10 years could be expected by the installation of one 4-in. by 20-in. 17-lb. rod for each mile of pipe.

The country traversed by the pipe line is laid out in square mile sections, therefore, it was possible to place the rods at section lines at all but 2 locations. At these locations, 2 rods were installed at both ends of a 4-mile gap. As a result, all rods are adjacent to roads and are easily reached.

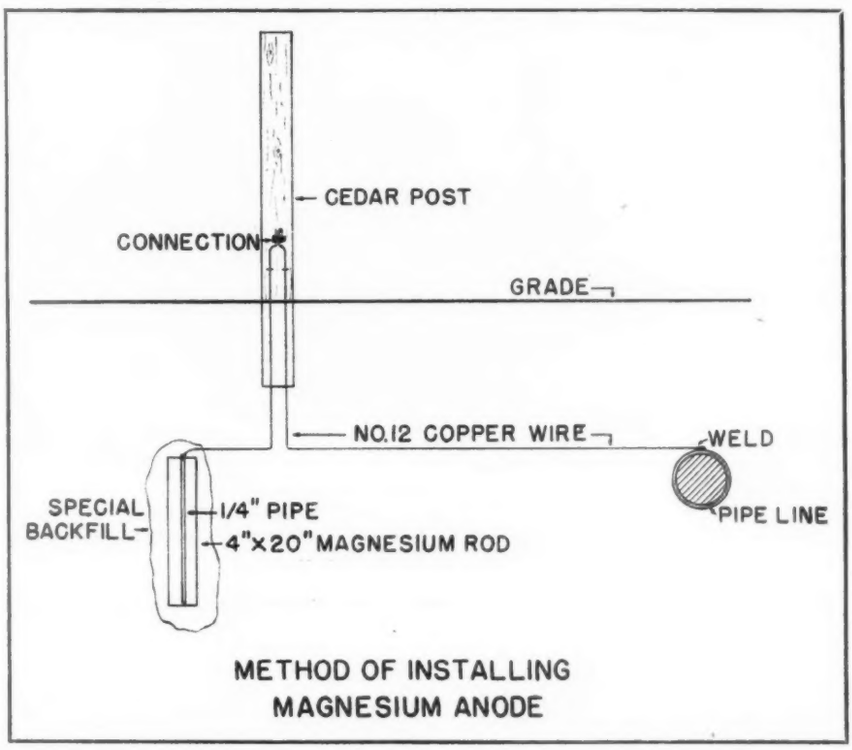
Before beginning the installation work the pipe line was uncovered, a spot on top was thoroughly cleaned, and the end of a 12-ft. piece of No. 12 waterproof insulated copper wire was brazed to the pipe. After hot doping the joint the wire was extended underground at right angles to the pipe for a distance of about 10 ft. and the end was then brought above ground and attached to a cedar post.

Each magnesium rod had to be equipped with a copper wire also. This was done by soldering the end of a 5-ft. piece of No. 12 insulated copper wire inside the top end of the ¼-in. piece of pipe that is cast in the center of the rod.

When this was done a paper thimble was placed over the connection and filled with hot dope in order to insulate the joint.

The backfill to be used was very carefully mixed dry, in a concrete mixer, and was placed in barrels for transportation.

The soil in which the rods were to be

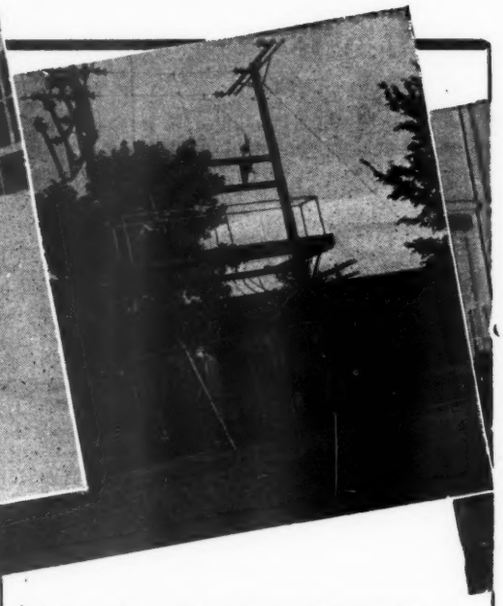


METHOD OF INSTALLING MAGNESIUM ANODE

*Corrosion, June, 1945, issue, published by the National Association of Corrosion Engineers.

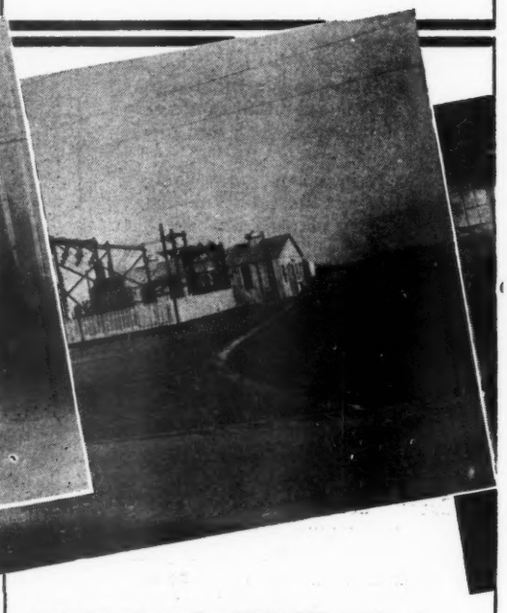
Power that keeps

A typical installation of motors and ventilating air ducts of a WEP 20" products line station.



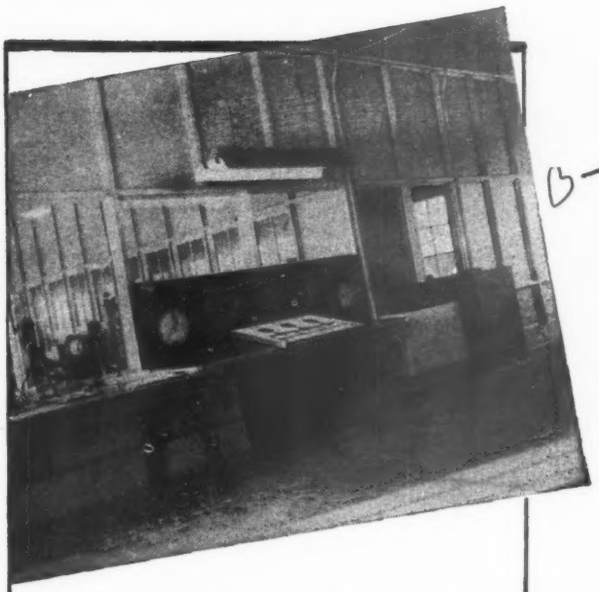
A transformer bank and transmission line to a main line major company pumping station in Oklahoma.

A typical example of how Utility Electric Power is being utilized for efficient and economical operation of pipe line stations throughout America.

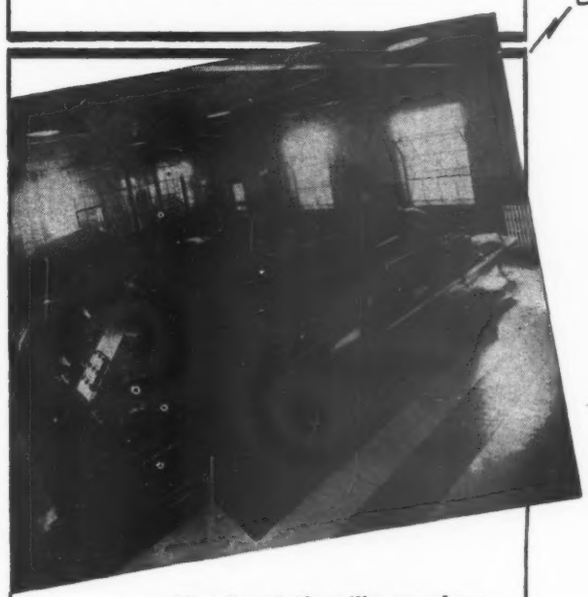


Exterior view of a WEP 24" crude oil pump station.

the nation's pipeline *Pulsing*



The control desk with view of the pump room through the glass partition in a WEP 20" products line station.



Pipe line stations like one above are delivering thousands upon thousands of barrels of oil and gasoline daily to vital points of distribution at rock-bottom costs.

In this post-war world, there is an ever-increasing demand for pipe lines, because it has been plainly established that they are economically sound for the transportation of petroleum products.

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buried was of a high resistant type, necessitating the following backfill mix:

2 parts aquagel
1 part annydrous sodium sulphate
1 part ground gypsum, hydrated ($Ca\ So_4\ 2H_2O$)

Hart and Titterington consider the selection of a backfill material of particular importance, in that the electrolyte is the controlling factor in reducing local cell corrosion of the anode surface. It, therefore, seems very important to pay particular attention to this part of an installation.

The work of installing the rods is rather simple and can be accomplished without much difficulty.

The chief part of the operation consists of digging the holes. A post hole digger is the best type of tool to use in the Gulf Coast area because the holes do not have to be more than 6 in. in diameter and 6 ft. deep, and unless the soil is very dry and hard such a hole can be dug in a rather short time.

Recommendations call for the top of the rod to be level with the top or bottom of the pipe, with the rods placed about 10 ft. from the line.

After the hole is dug the dry backfill is poured into the hole, water added, and the mixture stirred with a stick to the consistency of a slurry. With 2 or 3 in. of backfill in the bottom of the hole the rod is inserted and the backfilling continued until the rod has been covered to a depth of about 3 in. The wire attached to the rod is then extended below the surface of the ground to the cedar post to which the pipe wire is attached. The wire is then brought above ground and nailed to the post close to the other wire. A copper lug is soldered to the end of both wires so that they can be joined together with a screw and nut. This arrangement makes it possible to take readings at any rod location whenever desired. (See sketch).

These readings include pipe-to-earth potential, rod-to-earth potential, and a current reading of the closed circuit in milliamperes.

Such an installation enables the operator to keep a close check on his system without having to uncover any of the connections or search for them when readings are desired.

It also makes it easy to find any loose connections that may occur because the potential reading will readily indicate the condition should such be the case.

After each rod is installed, it is wise to take potential readings from pipe to earth, rod to earth, and a current reading of the closed circuit. These readings are obtained for comparison with the final readings to be taken at the time the rods are connected. None of the rods is joined to the pipe line, however, until all have been installed.

It is interesting to note the effect of the rods as each is connected.

For example, on this particular pipe line the potential of the pipe to earth, before any rods were connected, was somewhere between 0.52 to 0.75 volt negative using copper sulphate rods, but as soon as the first rod was connected the potential increased and it continued to do so as each rod was attached to the pipe. After all the rods had been connected the pipe-to-earth potential had increased to a point ranging from 0.90 and 1.15 volts negative, except at one location at which a tap extended to a distribution system. The potential at this point was 0.73 volt, but the amount can easily be increased if the distribution system is insulated from the pipe line. From these data it can readily be seen that the pipe line was fully protected by the rods because the pipe-to-earth potential of 0.85 volt or higher is considered to be the theoretical protective point.

The current being drawn from each rod varied from 22 to 55 milliamperes, an indication that full protection can be expected from this installation for a period much in excess of 10 years provided the rods do not become passive or cease to function for some other cause.

Since the completion of the installation, two other complete sets of readings have been taken but there was very little change in the amount of current being drawn from the rods. For example, the total current being drawn at the time of completion was 1780 milliamperes and at the time the second reading was taken, 30 days later, the total was 1720 milliamperes. The second reading, however, did show a decrease in pipe-to-earth potential but this was attributed to the fact that the soil surrounding the pipe had dried out considerably since the time of installation. The potential reading,

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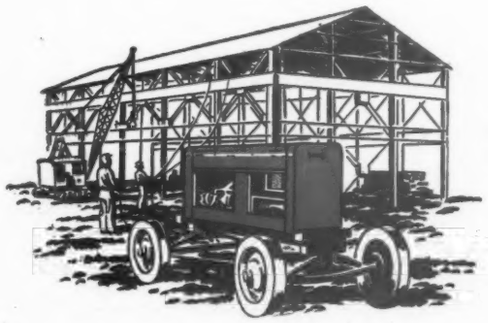

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nevertheless, was still within the protective range and it is expected that the potential-to-earth reading will increase with each heavy rain. It is likewise expected that the current output will increase as the pipe coating deteriorates. This, however, will probably not occur for several years.

Additional potential readings will be taken from time to time in order to keep a record of the rod performance so that a comparison can be made with data procured by others who are likewise conducting experiments.

Although this article has been confined to the discussion of the work done on a gas transmission line, this is by no means the only application of this type of cathodic protection. Installations have been made on steel piling, storage tanks, and other metal structures subject to electrolytic action, with varying degrees of success. The writer has witnessed some of the installations and was particularly interested in one method that employed a special electrolyte and ceramic jar. In this case the rod is placed inside the jar, the electrolyte poured around the electrode, and both sealed inside with a cap through which the electrode wire protrudes. The developers of this method, for which a patent application has been made, claim a higher efficiency of current output, ease of installation and maintenance, and a more constant rate of current discharge. These jars are also especially adapted to tank protection because the jars containing the rod and electrolyte can be lowered into a tank regardless of its liquid contents, and then will provide greater protection with the use of a minimum amount of magnesium.

It is also likely that the small cost of installation will make the use of the rods practical for spot protection of old pipe lines and distribution systems. For example, it may prove advantageous to install rods wherever pin holes or evidence of electrolysis has been found in order to arrest or eliminate future trouble at these hot spots. Such a course simplifies the practice in the case of transmission lines and no doubt will do likewise in distribution systems but in some instances it will be necessary to install insulators in service lines if full benefit is to be obtained on the mains.

As a matter of fact, the entire proposition is comparatively new and there is still much to learn, but as results have been highly satisfactory thus far, it appears that the practice should be continued.

★ ★ ★

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The foreign liquidation commissioner and army and navy petroleum board estimates that very little of the government's petroleum supply overseas will be declared surplus. There is perhaps 12 to 15 months' supply of aviation gasoline remaining, according to the petroleum board. As demands are estimated at about 1,000,000 bbl. a month, this would indicate total overseas government-owned stocks of aviation fuel of about 15,000,000 bbl. Some 1,000,000 to 2,000,000 bbl. of this is the most that can be expected to be declared surplus and handed over to the foreign liquidation commissioner for disposal. As the amount declared surplus will be in scattered lots at widely separated points, the probability is that in very few cases will the amount sold at any one time be of any size.

Some of the government overseas stocks may become the property of foreign nations, through so-called equity exchanges, in which this country will receive something regarded as more necessary in the area involved. The import need of nations being supplied through the United Nations Relief and Rehabilitation Administration, now undergoing screening in Washington, aggregates 266,500 tons of petroleum products a month.

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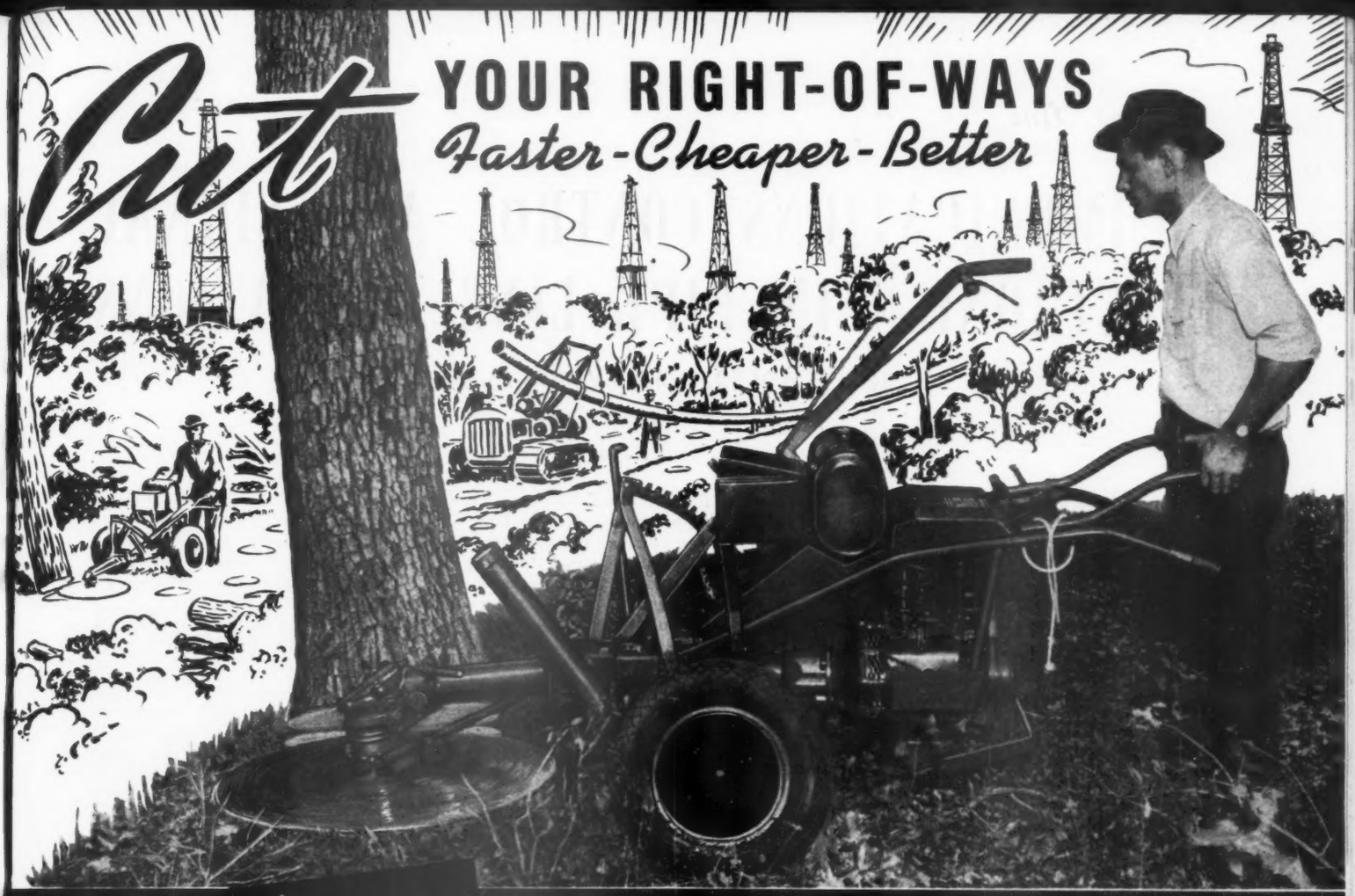

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P 615.36

COMMUNICATIONS CONTROL AND SIGNAL ELECTRONICS IN PIPE LINE OPERATIONS

By **L. E. ADLER,** *Communications Engineer*

Magnolia Petroleum Company

Foreword: All subject matter herein represents the writer's own views, opinions, and experience and does not necessarily reflect the views of any institution or institutions with which he is connected. —Author.

WITHOUT communication facilities, pipe lines and isolated producing fields would be practically worthless. There was also a time when pipe line pump stations would be useless without an operating crew.

EXCLUSIVE

Let's look at the picture in the light of new progress in technology, taking the various branches of the pipe line industry as examples.

● **Wire communication.** In the early days of pipelining, wire communication often consisted of a single iron telegraph wire using a ground return, strung on brackets nailed to a convenient pole line or even to trees and posts. It was strictly a "party line" proposition with a set of Morse instruments in each station and on the dispatcher's desk. It required three shifts of Morse operators in each station plus the regular force of engineers, oilers, and gaugers.

In those days labor and supplies were relatively cheap and there were neither profit taxes nor price ceilings on products or the transportation thereof. The business was run solely by the management, for the benefit of both the stockholders and the employes, without "help" from the "ism" boys. So no one was particularly worried about anything except the possibility of a break in the pipe line or the control wires.

In time, the telegraph gradually gave way to the telephone. It was not always easy to locate replacement telegraph operators in a hurry, but anyone could use the telephone, thus performing other duties besides communication. It was also much nicer for the dispatcher, superintendents, and other officials at headquarters to be able to talk with all of the boys along the line. It was even more important to have a system wherein a lineman or linewalker could call in from any point along the line to report a leak or break and, if necessary, call for an immediate shutdown for repairs. This one feature alone has saved oil wastage that even at a guess must run well into a total of millions through the years.

As operations expanded and pipe lines increased in distance and carrying capacity, the simple two-wire phone line with its one-voice channel and one simplex channel became unequal to the traffic and transmission requirements. So, about 16 years ago, the petroleum industry began to employ electronic and electro-mechanical devices such as telephone repeaters, teletype machines, and telephone carrier equipment, the last permitting the placing of one to three additional independent voice channels over one existing pair of physical telephone wires of the conventional type of construction.

Nowadays, other types of auxiliary communication are available; one of these is known as "facsimile" equipment. By means of facsimile, it is possible to transmit over any good telephone circuit (physical or carrier), any printed, written or pictorial subject, including maps, drawings, and bulletins in the exact image of the original, at the rate of 15 to 30 (or even more) square inches per minute. The attendant at the sending end merely inserts the document in the machine, starts the machine and then goes on with his routine duties. The attendant at the receiving end does likewise until transmission is completed. Simplicity of operation is such that any office boy or girl can send and receive as well as any high-priced operator or technician. Copies can be photostated or in some cases blueprinted, according to the type of facsimile paper used.

All the foregoing types of apparatus and equipment come under the head of "realities." Now let us use our imagination on the basis of how much further we might be able to go with new and improved instrumentalities.

● **Telemetering.** By means of a sufficient number of channels and the proper auxiliary equipment, all metering functions at any station could be transmitted to a distant office, such as a centralized dispatcher. This of course includes such metering indications as current, voltage, pressure, flow, and temperature. Some progressive companies are already employing one or more of these telemetering functions, not only over simplex or physical wire circuits but also via carrier-current to a considerable extent.

● **Signalling and control.** Like telemetering, various signal and control functions are also possible where an adequate number of channels are available. Among these are:

Bearing temperature alarm signals on motors and pumps. (sig.)
Fuse alarms and fire alarms. (sig.)
Power interruption alarms. (sig.)
Starting and stopping machinery. (control).
Operating valves or "gates." (control)
Gauging (really a form of "metering"). (control)
Gas detection. (control)

At this point, it is well to emphasize the fact that several different sets of readings or functions of certain types can be transmitted over one pair of wires or one carrier-channel by means of "step by step" automatic switches or relay-finder systems using pulse selectors that will automatically receive a reading from one station then pass on and pick up in turn readings from all other stations one at a time in successive sequence. All this may often be accomplished over existing wire facilities.

● **Problem of channel facilities over wires.** Up to the present time, nearly all wire channel facilities have been obtained by one or more of the following means:

1. Open-wire lines (for long distances).
2. Aerial or underground cable (for short distances).
3. Simplex or composite equipment for ground-return, single-wire circuits superimposed on open wire or cable lines, per item No. 1 or No. 2.
4. Telephone and/or telegraph carrier channels superimposed on open-wire lines.

In this connection, the following combination of channels are possible on one open-wire circuit having both wires properly transposed for frequencies up to 30 kilocycles and with 8 or 9-in. pin-spacing (excepting pole pairs, which are not recommended for carrier transposition).

(a) One physical voice channel.
(b) One simplex or two composite signalling or metering channels using ground return.
(c) Three telephone carrier channels or for each channel omitted, 8 or 10 telegraph, signalling or metering changes may be obtained.

It is possible in many cases to add the proper channel equipment to existing outside plant facilities and thus obtain more channels at a mere fraction of the cost of stringing additional wires.

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GENERAL
PIPE LINE CONSTRUCTORS

For The Oil & Gas Industry

QUALITY • EFFICIENCY • RESPONSIBILITY

During the twenty years prior to the war, we had built a specialized organization that was outstanding in the pipe line construction industry. During the war, this organization was used by us in many diversified activities. Our Management and men were made available wherever they were needed—in shipbuilding, airplane modification, training schools and on pipe lines in the United States, Canada and Alaska.

NOW, *the effective efforts they used in wartime production are being applied to the construction of oil and gas pipe lines so urgently needed for reconversion purposes.*

H.C. PRICE CO.

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LOS ANGELES BARTLESVILLE, OKLA. SAN FRANCISCO

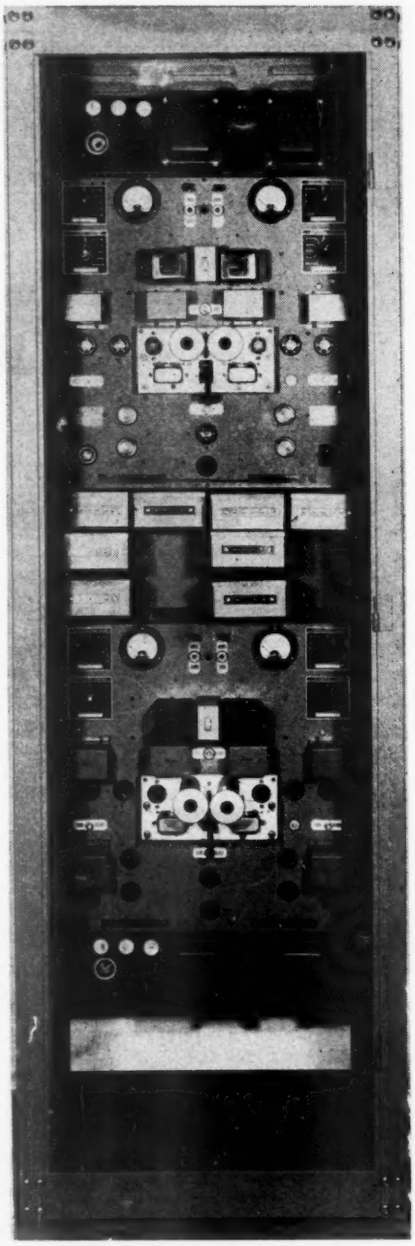
● **Possibilities of channel facilities over long underground cable.** Many of us have dreamed of this for many years but thus far the writer knows of no major installation of this kind in use by the pipe line or petroleum industry.

In general, the elementary principle is as simple as this:

1. Bury a properly protected cable (say 4 to 10 pairs), in the same trench as the pipe, with cable loading coils at 6600-ft. intervals and voice repeaters approximately 60 miles apart. Other than the groundless fear of the first guy ever to eat an oyster, there is no experiment involved in this plan. In fact, the Bell Telephone System has amply demonstrated the practicability over a period of years. The cost factor is one of the considerations, for pipe line executives and engineers who are seldom communication-minded seem to view with financial horror the thought of spending three per cent of the cost of the pipe line itself on communication facilities, without which the pipe line cannot be operated. Moreover, the possibilities of complete automatic operation of the line from the dispatchers' office and the consequent elimination of a major part of the operating payroll seems well worth careful and thorough analysis before "leaping." After all, the only real answer to labor problems is to be found in technology.

A brief analysis of channel possibilities via the underground cable route is in order at this point. With, say, a 10-pair cable loaded for voice with a cutoff frequency of approximately 2800 cycles, the following combinations are possible:

1. Ten voice channels (less one spare pair if desired).
2. For each voice channel omitted, 8 to 16 signal, control, telegraph, or printer channels are possible.
3. On each voice channel, a facsimile circuit can be obtained, either on a full-time basis or by merely switching the facsimile equipment on any voice channel at will. When switched off, the channel again becomes normal for voice use.
4. Under certain limitations, a single signal or control circuit can be superimposed on each voice channel without losing the use of the voice channel.



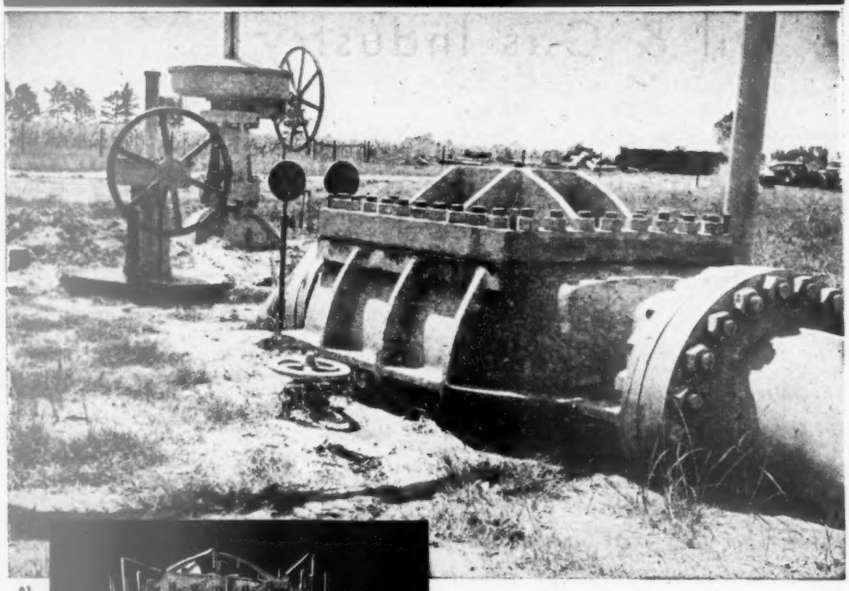
Telephone carrier terminal showing equipment for two carrier voice-channels mounted in one cabinet.

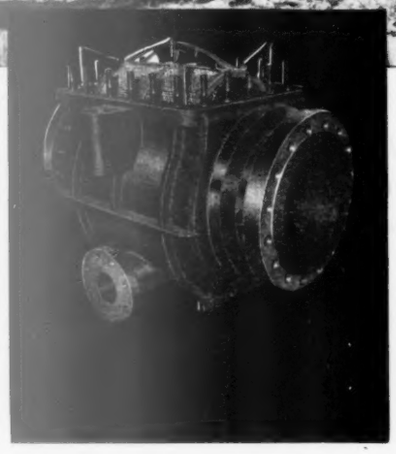
—Courtesy Southern Electric and Transmission Company.

WHEATLEY'S

Streamlined Strainer

for Maximum Efficiency





The WHEATLEY STREAMLINED STRAINER fits directly into the pipe line eliminating all drop pressure. The necessity of digging a pit, as is customary when installing the old vertical type, is also eliminated.

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Oil-field operations are a "natural" for FWD four or six-wheel drive trucks. Power on all wheels — controlled by the FWD center differential — gives these trucks the extra push to get through over the roughest terrain and in the most severe weather. With every wheel a live puller the hauling power is there — oil men know FWDs are dependable "prime movers."

Write for literature and complete information on the complete FWD line of four and six-wheel drive trucks for oil-field service.

FWD

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THE FOUR WHEEL DRIVE AUTO COMPANY
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Pipe Line

High frequency underground co-axial cable also has some interesting possibilities. Here a new problem arises due to the fact that repeaters must occur at intervals of only 5 or 10 miles, and the housing and current supply problem in isolated territory must be considered also. The possibilities of maximum number of channels are practically unlimited, provided economic justification exists.

Although the theory of co-axial wave guides is an old one, having been demonstrated mathematically by Heavyside many decades ago, its application to actual telephone service has been developed only during the last few years.

● **Radio communication possibilities.** Like commercial television, a considerable amount of "gun-jumping" has been done in respect to the application of radio in the pipe line and petroleum industry. Although it is somewhat difficult to hold this subject down to the non-technical attitude of the layman, it should be kept in mind that in the present stage of the art, certain fundamental limitations need to be overcome before long-haul use of F-M (frequency modulation) radio can be considered as a candidate to succeed wire communication.

Here are some of them:

1. Zone characteristics of F-M: As ultra high frequency F-M waves travel beam-fashion, like the straight line of vision, their distant range is ordinarily limited by the curvature of the earth itself and by terrain obstacles such as hills, tall trees, tall buildings, etc., all of which intercept or "bounce back" (like radar). For this reason, unless one dreams of antenna towers of fantastic height or antenna mounted on balloons or kites, the normal range of a 50-watt F-M transmitter in the 35 to 42 megacycle spectrum will *normally* in *flat country*, seldom exceed 15 to 30 miles to mobile sets and 20 to 50 miles between tower stations. Longer spans are obtained occasionally on "freak" days. Nor does it help materially to increase the power to 250 watts or more.

2. Extending range by means of "radio relay" or "repeaters." Sure it can be done, if FCC authorization can be obtained; but here we encounter other difficulties, principally the interference angle and the small number of frequency assignments available. For these reasons, a long series of "hop-hop" repeater stations such as would be required to operate a pipe line several hundred miles long would merely result in a national "party line" hook-up on which the strongest wave would predominate. Not only would the dispatcher pick up a few contemporaries in his own vocation, but also a myriad of regional police calls, etc. In other words, with a bare handful of frequency assignments available, there is no such thing as any user having a clear channel all to himself such as now exists in the broadcast band.

In addition to limitations of earth curvature, terrain obstacles, etc., even radio of the F-M type is subject to "man-made static" in many locations where the receiving power levels are too low to override the noises of defective power line equipment, centrifuges, diathermy, X-ray and other equipment throwing off high frequency harmonics. Moreover, that phenomena of Dame Nature known as "sun spots" may "kill" short wave reception for hours at a time, even days.

Although normal operation of F-M within a 50-mile radius has many useful applications, considerable development work and inventive ingenuity will be required before we can truthfully exclaim, "Why spend $200 to $700 per mile for wire facilities?"

Ultimately, the writer believes that the present number of available frequency bands will be multiplied many times by such means as the use of narrow transmission bands separated by crystal filters along with greater frequency stability to eliminate drift trouble on narrow bands.

● **Introspection.** The writer has endeavored to avoid "writing a book" on the subject at hand, the sole purpose being to present a condensed thesis on past and present practices and future possibilities. This is a young man's era. Thousands of technical minded youngsters are pouring out of the armed services, some with both basic and specialized training and experience. Among them there are many who are bound to find the answers that we need to go forward in industrial communications, signalling, and controls. As our friends say South of the Border, "Quien Sabe?" ★ ★ ★

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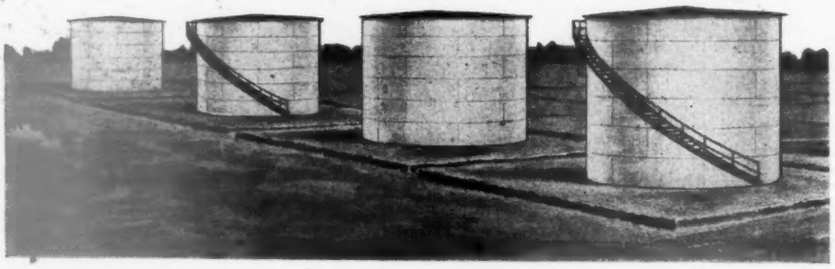
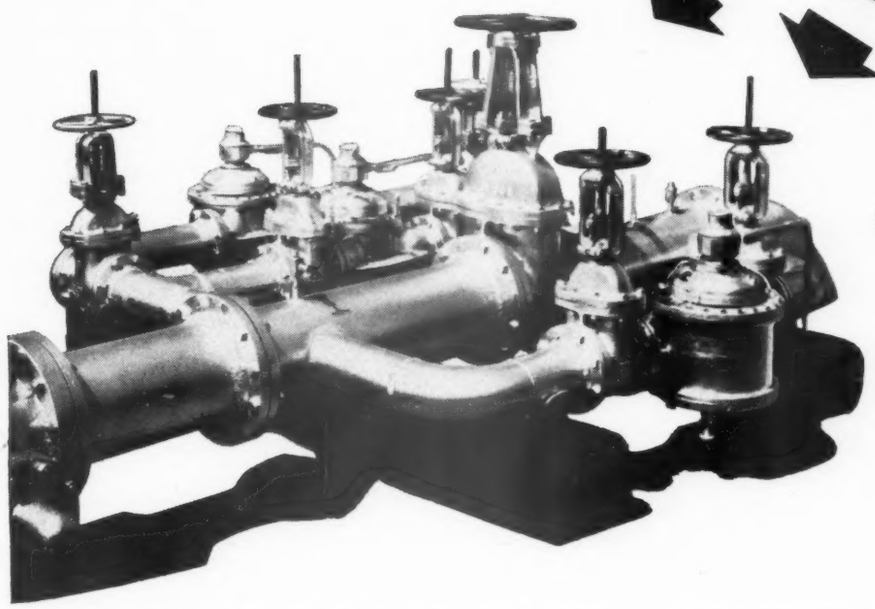


ACCURATE PIPE LINE MEASUREMENT



All Smith Meters are built on the simple SMITH ROTARY PRINCIPLE, dependable, accurate and fast, *the design that revolutionized the meter industry.*

At this crude oil pipe line gathering station, three Smith Model S Meters are mounted on the suction side of the pump. A recording instrument mounted on the panel board indicates their total rate of flow, registers total through put and records rate of flow on a 24-hour chart. The sum of the three meters is recorded on the one instrument. Control panel may be located at any desired distance away.

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NEW $4,000,000 CALIFORNIA PIPE LINE

ESTIMATED completion date of Standard of California's new $4,000,000 pipe line, to link San Joaquin Valley oil fields with San Francisco Bay area refineries, has been advanced to the middle of the year.

EXCLUSIVE

It was originally expected that the 176-mile line would be put into operation about May 15, four months after actual pipe laying operations began; however, the steel industry labor tieup has delayed delivery of pipe for the new line.

Alteration of original plans, to include a booster pump station near Los Banos, will increase pumping capacity of the 18-in. line from an estimated 85,000 to 110,000 bbl. a day, to be delivered to Standard's Los Medanos tank farm near Pittsburg, which supplies oil to the Richmond refinery. The crude will be gathered from Kettleman Hills, Coalinga, and other San Joaquin Valley fields and pumped from existing stations at Kettleman Hills and Coalinga.

Steam turbine-driven centrifugal pumps at Kettleman will give initial impetus to the oil cargo, and can maintain a pressure of 940 lb. per sq. in. Equipment to be installed in the Los Banos booster station will be capable of adding 650-lb. pressure to the line at the point and the resulting 750-lb. discharge pressure will be sufficient to carry a capacity load 80 miles to the Los Medanos tanks. To withstand initial pressure at these two pumping stations, special high-strength pipe will be used for 41 miles north of Kettleman Hills and for 19 miles beyond the Los Banos station. Kettleman station will require no major additions or changes, nor will Los Medanos.

The new line, a cold oil system, will handle only San Joaquin Valley light and Kettleman type crude oils. Heavy crudes, other oils and natural gasoline will continue to be moved to Estero Bay for tankering to Richmond and other consignment ports.

Completion will permit the Stanpac line to be reconverted to transportation of natural gas from San Joaquin Valley fields. Stanpac was changed over from natural gas to crude petroleum early in 1942, as a supplement to tanker service then under danger of submarine attack. Emergency use of the natural gas line for oil transportation up to 185,000 bbl. a day is credited with having made possible production records set by the Richmond refinery. Stanpac is owned jointly by Pacific Gas and Electric Company, Standard of California, and Pacific Public Service Company.

Specifications for the new valley line call for three innovations in pipe line construction. In use for the first time by the company is electric-weld pipe with extra high yield points produced by stretching the metal by internal hydrostatic pressure. This type of 18-in. pipe will be laid on 167 miles of the project. Twenty-inch pipe will be used on the other 9 miles of the new line. In addition to this new type pipe, gamma ray pictures of welds will be made and construction will include the pressure-welding process.

The steel in the normal strength new pipe has a specified minimum yield point of 45,000 lb. per sq. in. The high-strength pipe has a minimum yield of 52,000 lb. per sq. in., and an ultimate strength of 72,000 lb. per sq. in.

The gamma ray photos "spot-check" a number of the welds daily, and constitute an interesting method of making accurate field tests of weld quality. The photo negatives, packaged in lightproof strips, are wrapped around the weld. A piece of radium is then lowered through an opening to a position approximately in the center of the weld's diameter. The rays thus emanating from the radium go through the weld and defects are recorded on the negative.

Construction of 40 miles of the pipe line is a field test by Standard of California of the semi-automatic pressure-welding process. The machine grips the pipe line, heats the pipe ends to be welded, and then forces them together under great pressure when the heated metal becomes malleable. The result is a forced fusion made without the use of welding rods.

Corrosion protection will be provided by the use of Somastic pipe coating on 100 miles of the line in the more corrosive areas. Asphalt and fabric wrapping will be used on pipe being laid in non-corrosive soils. Route of the line, which parallels Stanpac along the western rim of the San Joaquin Valley, avoids any

Removing mold after coating of field weld on Los Medanos pipe line.

Photos by Standard of Calif.

ENGINEERING, CONSTRUCTION — FOUNDATIONS OF PROGRESS

OIL Paces Transportation

On the Standard Oil Company of California's Kettleman Hills 18-inch oil line BBM is pioneering three new construction procedures. *Result:* fast, efficient construction—greater line permanence.

From central California to the San Francisco bay area this BBM line will stretch 178 miles over hills and plains.

Three "firsts" in pipe line construction—narrow width welding, gamma-ray photography, and the use of SOMASTIC coated pipe in *80-foot lengths*—are being employed on this important new oil line. As constructor, our responsibility is to integrate the new procedures with established methods—keeping work on schedule, at economical levels.

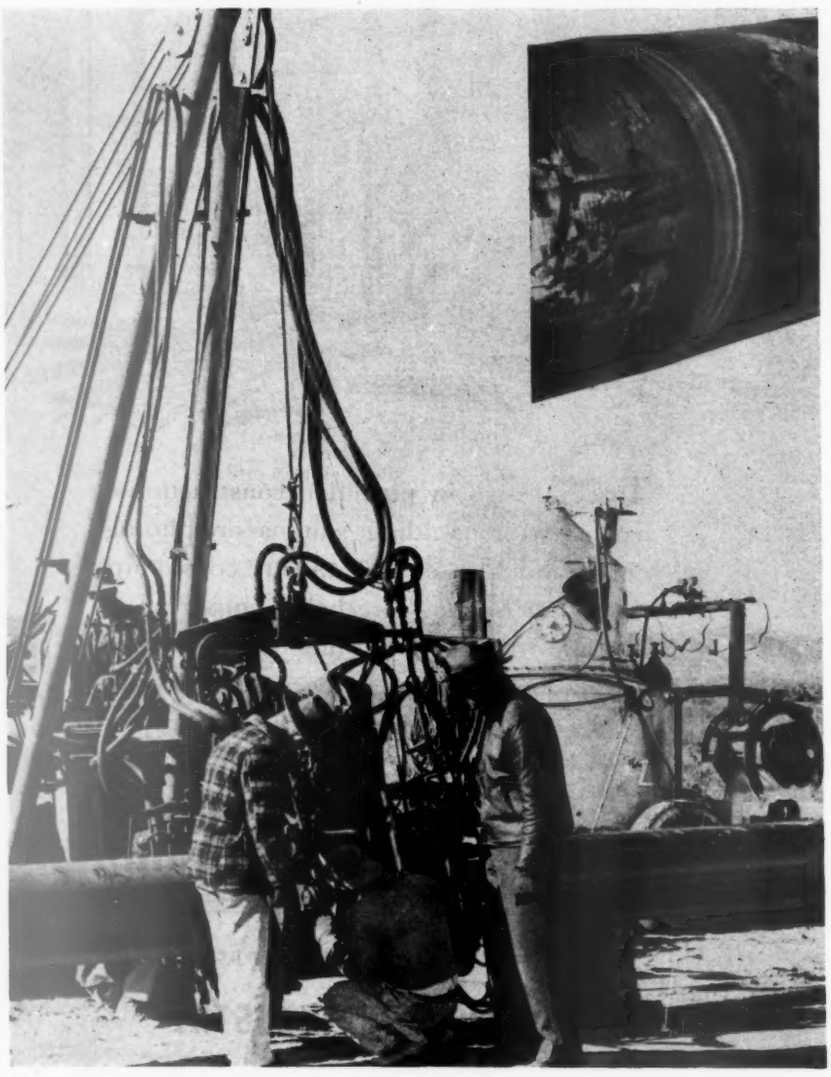
Bechtel Brothers McCone Company

ENGINEERS ★ CONSTRUCTORS

San Francisco BBM Los Angeles

BUILDERS FOR INDUSTRY

Above, making a field weld. Below pressure-weld machine in operation. Insert, newly made pressure weld.



large areas of corrosive ground, a chief hazard to continued operation of underground pipe lines.

As an aid to dispatching of crude oil volume, telemeter circuits will be provided on the company's existing telephone system that will transmit flow meter readings from both ends of the line and from Los Banos to the gauger's office at Los Medanos terminal.

The new line is the second to be built by Standard to the San Francisco Bay area from the San Joaquin Valley fields.

For 25 years prior to 1929 all valley crude oil was moved to Richmond refineries through a 280-mile 20-station trunk line from Bakersfield, but because of small-sized pipe and the numerous pumping stations it was a costly system to operate. Therefore, with the discovery of oil in Kettleman Hills it was found more economical to take this oil out by a new route direct to the nearest deep water at Estero Bay, which became a loading port for Standard tankers and made crude equally available to both Richmond and El Segundo refineries.

In 1934, when extensive pipe replacements were imminent, the Bakersfield-Richmond system was abandoned in favor of another line to Estero Bay. Thus crude oil from all valley fields was handled via Estero Bay until war conditions in 1942 removed tankers from the Richmond run, and the Stanpac line was converted.

Now the increased quantities required by San Francisco Bay refineries exceed the capacity of lines to Estero and make construction of the new line feasible.

Construction contract for the new line was awarded to Bechtel Brothers-McCone Company. Pipe for the project is being supplied by A. O. Smith Corporation of Milwaukee. ★★★

BS&B PIPELINE OIL SEAL VALVES AND STEEL TANKS

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B S & B
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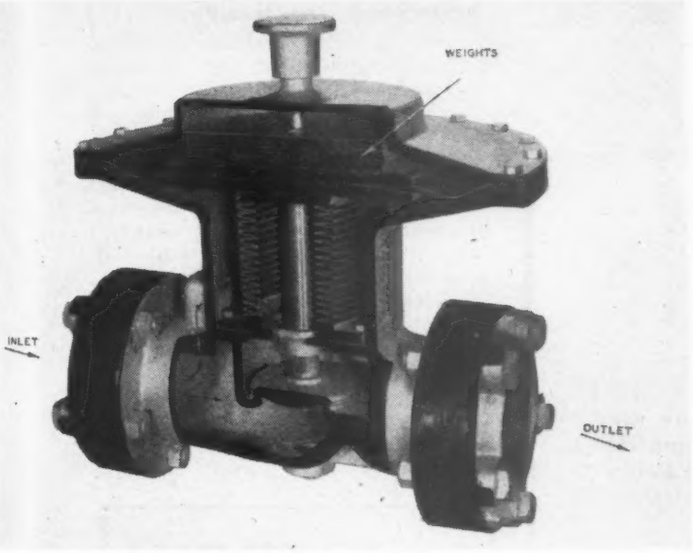

Cutaway View of the B S & B Pipeline Oil Seal Valve

An outstanding feature of the B S & B Pipeline Oil Seal Valve is that it is automatic in operation. It requires no manual setting or adjusting* with each run and no hand venting of air before each run. When a tank of oil is ready to be run, open the gate or stop valve located between the oil seal valve and the tank. The oil seal valve will close when the head of oil in the tank is near the bottom.

Vacuum has no effect on the operation of the valve because the effective area of the sylphon bellows is the same as that of the valve plug itself.

Here is a valve that is AUTOMATIC and positive in operation.

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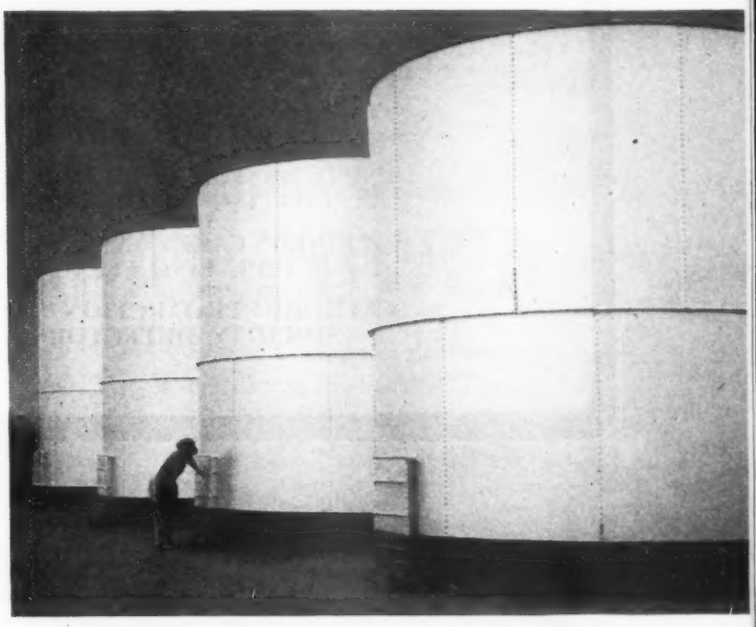

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OKLAHOMA CITY

Robertson reminisces*

When I think that an 8-in. mainline was the largest oil line we laid in the early 20's, and that the pipe was laid by 60 men on a gang, making up each screw joint with lay tongs, I can appreciate the old pipeliner a lot. And when practically all the ditch was dug by hand at $2.50 per man, for an 8-hr. day, even in this thriving metropolis of Los Angeles, I can appreciate the old pipeliner more.

Today the main oil line is 20 in. and the gas line is 26 in., all electrically welded in 40-ft. lengths, laid by sidebooms, tractors and cranes, and not by tongs, when each man carried 100-lb. in 20-ft. joints. Now we get an order to lay an oil or gas line at the rate of a mile a day, and if the materials are there and the right-of-way procured by the engineer, it merely takes a number of gangs to lay a like number of miles a day, according to the terrain and conditions. Now we can appreciate the experience passed down by the old pipeliners to the younger superintendents and managers of today, who align and weld our "small inch" or "big inch" gas lines with modern ditching machines, electric generators, sidebooms and equipment, and who can deliver a tested job right on schedule.

These older pipeliners have also developed and passed on to us many safer construction methods. I believe that safety should be the first consideration of a pipe line contractor, and that the quality of work done for a customer is of paramount importance.

To the old pipeliners we take off our hats, for through these hardy pioneers we have learned the know-how, so that the younger man of today takes over the reins and delivers a better joint, a better and bigger job in much less time. The old pipeliners' experience and the younger men's new ideas played a great part in fueling our armed forces to victory. Wherewith we express our sincere appreciation to the oil and gas pipeliners of yesterday.

*Alex Robertson is a pipeliner of many years' standing. He is the Robertson part of Macco-Robertson, pipe line construction contractors.

American pipeliners

Since the first petroleum pipe line, built in Pennsylvania in 1865, enterprising American pipeliners have honeycombed the United States with lines and have undertaken construction of many more abroad. Before the "Big Inch," the largest diameter oil line in the world, was the 100-mile, 16-in. line in eastern Venezuela owned by an American firm.

American pipeliners covered the war areas with lines to feed the war machine. Pipe lines were thrown across vast spaces, over plains, around mountains, and under the sea.

Pipeliners are a peculiarly American breed, deterred by nothing that nature throws in their path, carrying their know-how and endurance and enterprise all over the world.

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with these products designed to aid you in your war against its destructive effects. We offer you complete corrosion protection for all kinds of above and below ground piping and every type of pipe line structure.

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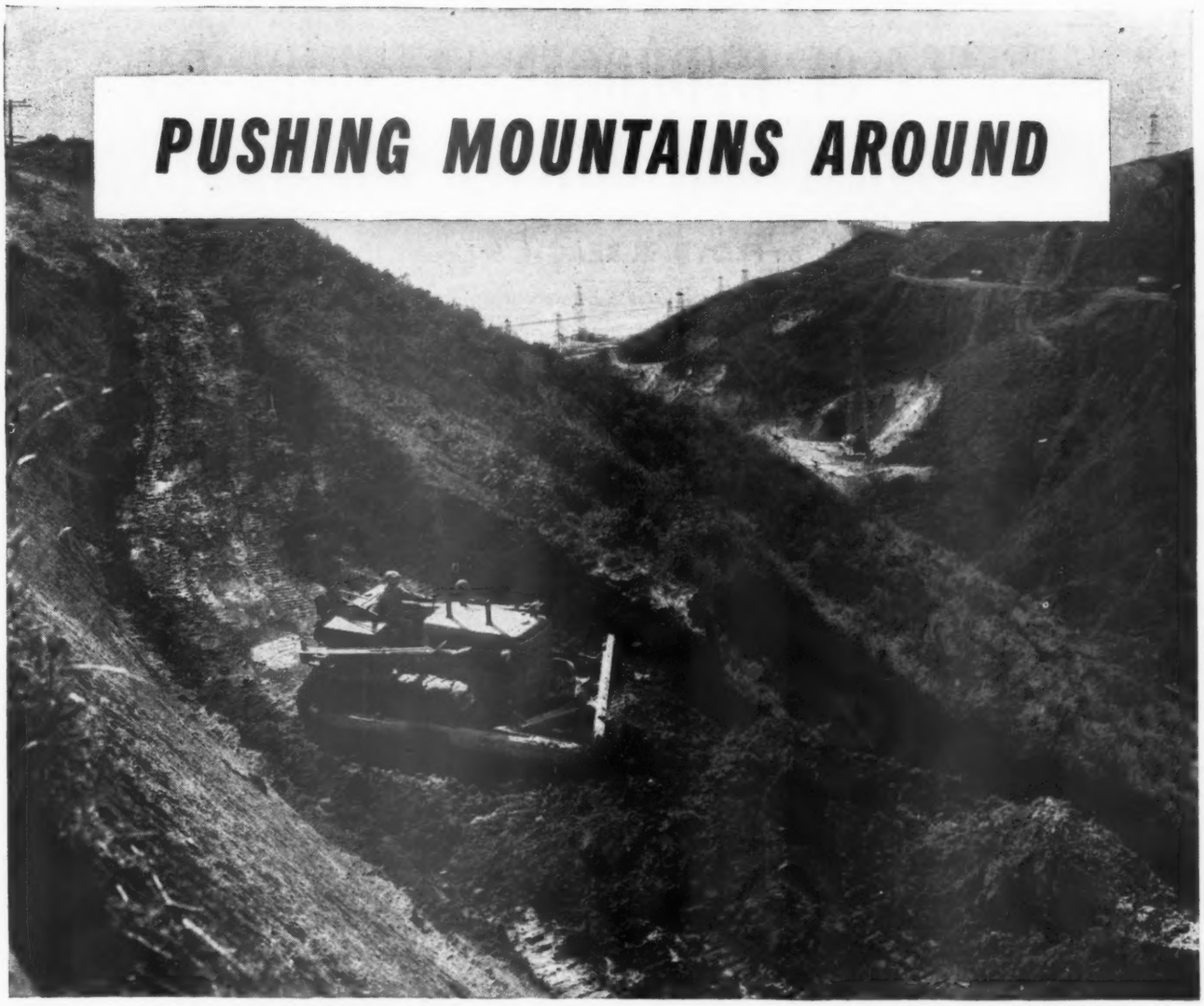

with INTERNATIONAL POWER

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EFFECT OF HYDROGEN SULPHIDE ON COEFFICIENT FOR ORIFICE GAS METERS

By **FLOYD K. BEACH,** *Engineer*

Petroleum and Natural Gas Conservation Board of Alberta

EXCLUSIVE

Gas Measurement Committee Report No. 2 of the American Gas Association has been adopted by the Alberta Conservation Board as basis for metering natural gas through orifice meters. That report tabulates values of variables in the general formula for orifice meter coefficient except for the value F_{pv}.

Report No. 2 is dated May 6, 1935. At that time various investigators had done considerable work on deviation from Boyle's law for perfect gases, or its inverse, supercompressibility. Van der Waal's equation[1] had been proposed and constants for numerous gases had been evaluated. Diehl[2] had proposed a formula giving weight to the most usual constituents of natural gas. Neither of these proposals recognized that deviation is a function of temperature as well as pressure. Work by Hamline, Kvalnes, and Gaddy in 1931[3] on methane showed deviation at 4 selected temperatures from 32°F. to 212°F. and pressures up to 700 atmospheres and showed that deviation varied with temperature as well as pressure. Cope, Lewis, and Weber[4] in 1931, and Brown, Souders, and Smith[5] in 1932 showed that for gases composed of a single hydrocarbon the theorem of corresponding states is true. That is, for a given "reduced" temperature greater than critical, and a given "reduced" pressure, every gas has the same deviation factor. In this definition reduced conditions are the ratio of actual to critical temperature and pressure. Temperatures for this purpose are in degrees Rankine or 460 + °F. In 1936, Kay[6] carried the theorem to mixed gases if "pseudo" critical conditions are used, and he found by experiment that the pseudo-critical temperature of mixed gas may be closely approximated by giving molal value to the critical temperature of the constituents of the mixture. That is, the fraction by volume of methane multiplied by critical temperature, plus the fraction by volume of each other constituent multiplied by its critical temperature, gives a summation very close to the pseudo-critical temperature of the mixture as found by experiment. Similar procedure arrives at pseudo-critical pressure. In other words, one may calculate the pseudo-critical conditions for a mixed gas and apply them to the graph for any gas with expectation that the result will be materially correct.

Also in 1936, California Natural Gasoline Association[7] showed that for gas consisting essentially of hydrocarbons, specific gravity is a sufficient criterion of deviation at any temperature and pressure, and published tables giving values of F_{pv} in the orifice meter formula for gases ranging from 0.545 to 1.50 specific gravity, for temperatures 40 to 150°F. and pressures up to 500 lb. per sq. in. abs. Values are listed for each 100-lb. pressure and consequently need only a little interpolation before applying them to orifice meter computations.

In 1940, Dotterweich[8] reviewed the work of some of the above mentioned authorities and referred to other authorities not again quoted here. He presented a graph showing the relation between reduced pressure, temperature and deviation, carrying the reduced pressures up to 7 and reduced temperatures up to 1.7, but the published chart is at too small a scale for ready use in metering problems.

Result of this study of high concentrations of hydrogen sulphide was that current procedure in gas metering was not affected.

Also in 1940, Dr. George G. Brown[9], working along parallel lines, showed that pseudo-critical values are very closely a function of specific gravity, and in his paper gave graphs from which pseudo-critical values may be read for hydrocarbon gases even when containing some nitrogen and carbon dioxide. He also gave a graph for methane showing supercompressibility at reduced temperatures from 1 to 4 and reduced pressures up to 13. In his article, he recommends deducting from the values of Z = PV/RT about 0.01 for each 1000-lb. pressure in case of mixed gases. Brown's graph of compressibility for methane has been reproduced in *The Petroleum Engineer's* Continuous Tables as P771.001, and his graphs of pseudo-critical values for hydrocarbon mixed gases as a function of specific gravity as P214.000.

In 1942, Dr. D. L. Katz and associates published a paper[10] prepared in line with the work of Dr. Brown[9] and he presented graphically factors that can be read more accurately and easily than the Brown chart for methane. He added a graph showing pseudo-critical values as a function of specific gravity similar to P214.000 mentioned above; he showed the places on it where 150 mixed gases fall, and he distinguished between hydrocarbon mixtures and those containing nitrogen and carbon dioxide.

The Petroleum and Natural Gas Conservation Board of Alberta has prepared a graphic representation of CNGA tables covering the range of gravity encountered in Turner Valley and has issued it for use in that field. It is reproduced as Fig. 2 of this article.

None of the authorities quoted go into the effect of hydrogen sulphide on F_{pv} or on pseudo-critical temperature and pressure. Turner Valley gas contains this constituent and numerous analyses are available that suggest that, although the content at the central and southern part of the field is of the order of 1 per cent or less, gas from the north end, particularly from low gas-oil ratio wells, may approach 8 per cent.

The questions now arise:

1. Are values for F_{pv} as currently in use, based on CNGA tables, essentially in agreement with the work of Drs. Brown and Katz?
2. What is the effect of hydrogen sulphide on F_{pv}?

Notation. CNGA notation, F_{pv} is used in the same sense as Report No. 2 of AGA. Brown and Katz use the notation F_Z in the same meaning and equals $1/\sqrt{Z}$ where Z = PV/RT. Katz uses a notation F_{GTZ} for a factor including corrections for gravity, temperature and supercompressibility, and makes $F_{GTZ} = \sqrt{520/GTZ}$. Therefore, to find $F_{pv} = F_Z$, one may multiply Katz's values of F_{GTZ} by $\sqrt{GT/520}$

G = specific gravity of gas compared with air as unity.
T = temperature, deg. Rankine = 460 + °F.
T_c = critical temperature.
pTc = pseudo critical temperature.
T_R = reduced temperature.
P = pressure, lb. per sq. in. abs.
P_c = critical pressure.
pPc = pseudo-critical pressure.
P_R = reduced pressure.
R = gas constant of 10.71.
V = volume, cu. ft.

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Comparison.

		P = 0	P = 500
For G = 0.70, T = 520 or 60°F.			
Katz Fig. 10	F_{GTZ}	1.195	1.270
Equate to	F_z	1.000	1.063
CNGA	F_{pv}	1.000	1.0628
For G = 0.70, T = 540 or 80°F.			
Katz Fig. 10	F_{GTZ}	1.173	1.235
Equate to	F_z	1.000	1.053
CNGA	F_{pv}	1.000	1.0540

This comparison shows that at the maximum pressures covered by CNGA tables, Katz's values of F_z are materially the same as CNGA values of F_{pv}, Katz's value being .02 per cent greater than CNGA at 60°F., and 0.1 per cent smaller at 80°F. Considering that Katz's graph cannot be read as closely as the apparent difference and that such differences are considerably smaller than errors due to lack of refinement ordinarily encountered in measurement of temperature and pressure, we may conclude that the two authorities are essentially in agreement, and the answer to our first question is "yes." Before fully agreeing in this answer to our first question, several analyses of Turner Valley gas were examined and the pseudo-critical values were plotted on Katz's graph (Fig. 5 in his paper), which has been reproduced as Fig. 1 of this article, leaving out the details Katz gives of 150 natural gases, but entering the 3 analyses for which values were computed as A, B, and C.

The analyses were made by Rosewarne and Offord of the Dominion Mines Branch and reported in a publication[11].

It was explained that one portion of each gas sample was fractionated in a Podbielniak column after a wash that would remove carbon dioxide and hydrogen sulphide. Another portion of each sample was tested in Burrell type apparatus for determination of carbon dioxide, oxygen and nitrogen, whereas another portion of each sample was used to determine specific gravity. Some of the analyses total more than 100 per cent of all constituents and we have taken some liberties with them in order to make them total only 100 per cent. The analysis was then tested for specific gravity by components for comparison with measured specific gravity. (See table at left.)

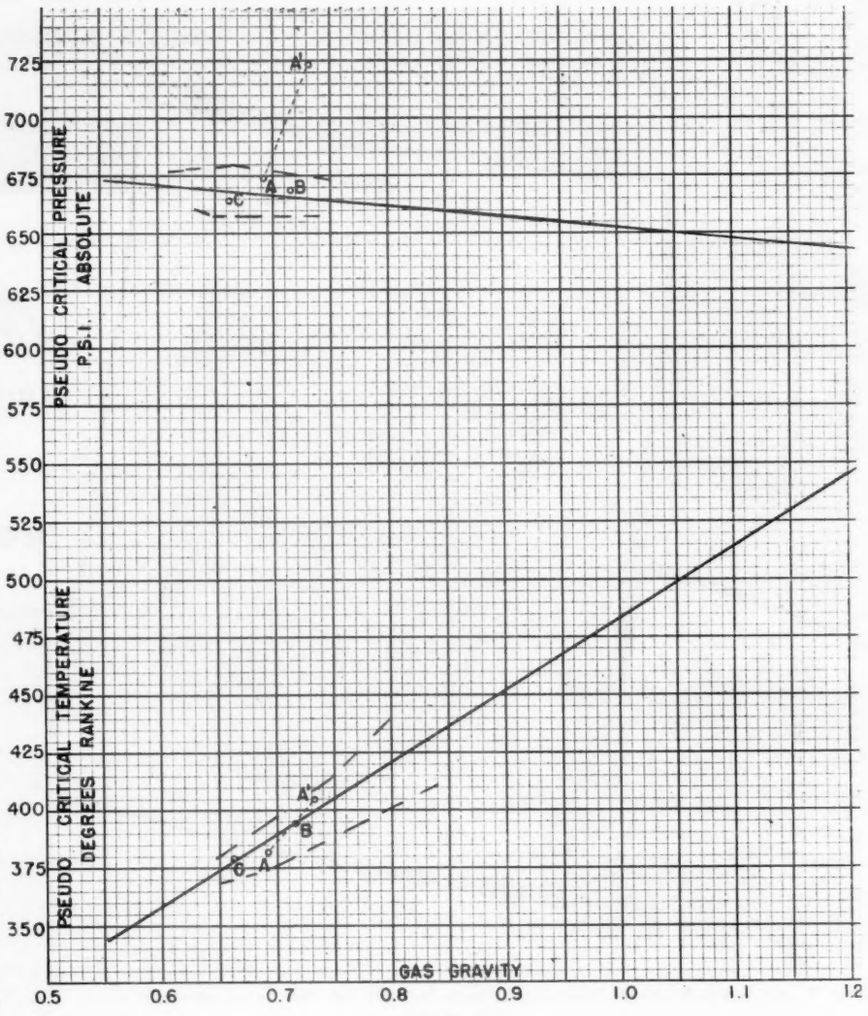

FIG. 1.

FIG. 1. Pseudo-critical values. Median maximum and minimum values for hydrocarbon gases (from Katz) and effect of 8 per cent hydrogen sulphide in a hydrocarbon gas.

Specific gravity by components vs. measured specific gravity.

Gas A — Advance 5A — G (as measured) = 0.691

1 Constituent	2 Reported volume, per cent	3 Adjusted volume, per cent	4 Specific gravity of constituent	5 (col. 3×4) / 100
Methane plus	87.2	86.1	.555	.4779
Ethane	6.6	6.6	1.046	.0690
Propane	3.7	3.7	1.546	.0572
Butanes	1.7	1.7	2.068	.0351
Pentanes plus	0.8	0.8	2.606	.0208
Carbon dioxide	1.12	1.1	1.528	.0168
Oxygen	0.29			
Helium	0.008			
	101.418	100.0		.6768

Computation of pseudo-critical temperature and pressure.

1 Component	2 Mole fraction	3 Critical temp.	4 (2×3)	5 Critical pressure	6 (2×5)
Methane	0.861	344	296.0	673	579
Ethane	0.066	550	36.3	712	47
Propane	0.037	666	24.63	617	22.81
Butanes	0.017	749	12.73	547	9.29
Pentanes	0.008	838	6.70	484	4.87
Carbon dioxide	0.011	548	6.03	1072	11.79
			382.39		673.76

As most Turner Valley gas averages a nitrogen content of about 1 per cent and carbon dioxide content of about 2 per cent and as hydrogen sulphide in this area might be ½ to 1 per cent, the analysis appears to be worth testing for critical values. Those constituents and in the proportions mentioned, would probably account for the spread between gravity of 0.677 computed and 0.691 measured. In adjusting the volume, oxygen was rejected as probable contamination of the sample, and helium as insignificant.

Note also that instead of working from molecular weights we have used specific gravity of each constituent as given in *The Petroleum Engineer* Continuous Tables, P771.001A, after affecting sp. gr. of a perfect gas by deviation factor. Had we worked from molecular weights, the calculated sp. gr. would have been 0.672 rather than 0.677. (Table at left.)

Gas B, Baltac, whose analysis was given in the same publication, contained 2.12 per cent nitrogen and following the same procedure its computed G was 0.710 against measured G of 0.715 and

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computed pseudo-critical pressure 669, pseudo-critical temperature 394.

Gas C, was a more recent analysis, also by Rosewarne and reported in a letter. It was gas that had passed an absorption plant, had computed G of 0.659 against 0.661 measured, pseudo-critical pressure 664 and pseudo-critical temperature 379.

Values of calculated pseudo-critical conditions for the 3 gas analyses have been plotted in Fig. 1 against measured specific gravity. Note that all fall quite close to Katz's median and well within the outer limits of the 150 analyses he used to derive the average.

It was therefore considered that use of Katz's median values for 150 natural gases is a reasonably accurate procedure for Turner Valley gas if free from hydrogen sulphide.

● **Effect of hydrogen sulphide.** Most analyses for hydrogen sulphide are made on the spot where the sample is taken and cover that component only. This procedure is due to the tendency of sulphur to combine with iron containers and to be affected by absorption in crude oil and salt water.

U. S. Bureau of Mines R.I. 3128 describes the technique ordinarily used and cautions against use of stagnant gas in contact with casing, for the casing will take up sulphur. It also mentions the hazards of solution in oil and hence the variable results obtained if the usual producing conditions are upset as to pressure and temperature. These cautions are fully borne out on perusal of analyses from neighboring wells at a given time, or from the same well at different times, and one feels that generalizations are better than great accuracy in dealing with any one analysis. These generalizations for Turner Valley lead one to observe that gas from the central and southern parts of the field contains from ½ to 1 per cent hydrogen sulphide, whereas a few wells in the north end of the field may run to nearly 8 per cent. The greater the gas-oil ratio the less hydrogen sulphide.

The basis of judging per cent hydrogen sulphide is that the chemist uses a factor of 630 grains per 100 cu. ft., as equivalent to 1 per cent. His titration of sulphur against iodine solution with dilute starch solution as indicator may be worked out to per cent hydrogen sulphide and then converted by a factor of 630 so we may merely reverse the process.

Now examine the effect on Gas A under the worst conditions, assumed as 8 per cent hydrogen sulphide. Presence of this impurity affects specific gravity as well as pseudo-critical pressure and temperature.

Accept the following as proper values for hydrogen sulphide based on P 771.001A *(The Petroleum Engineer* Continuous Tables).

sp. gr. = 1.189 = 1.176 × deviation factor 0.011.

Tc = 672.3.

Pc = 1306.

Let G = sp. gr. of a gas having no hydrogen sulphide.

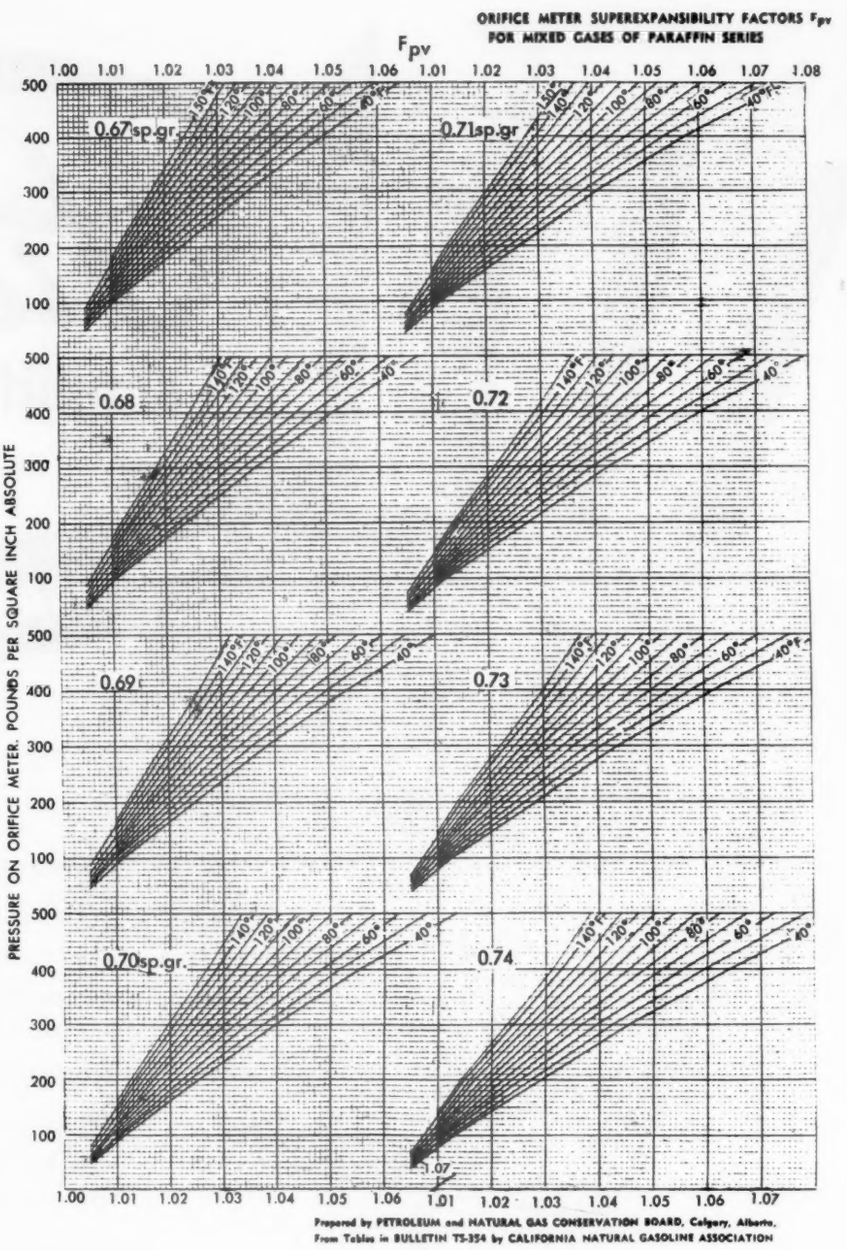

FIG. 2.

G_m = sp. gr. of same gas after mixing with H_2S.

x = H_2S fraction.

Then $G_m = G(1 - x) + 1.189x$.

Rearrange for ease in assessing effect of variable proportions and $G_m = G + x(1.189 - G)$.

For Gas A having G = 0.691.

$G_m = 0.691 + 0.08(1.189 - 0.691) = 0.691 + 0.08 \times 0.498 = 0.731$.

The effect on pseudo-critical pressure will similarly be found for the mixture as:

$674 + 0.08(1306 - 674) = 724$.

And on pseudo-critical temperature as:

$382 + 0.08(672 - 382) = 405$.

These have been plotted on our Fig. 1 as A′ positions and have been connected with A positions to show the effect of this assumed maximum concentration of hydrogen sulphide on the pseudo-critical values of Gas A.

For P = 500, T = 520 we can tabulate for Gas A (without hydrogen sulphide), and Gas A′ (with 8 per cent hydrogen sulphide) the figures show below:

Gas	pPc	P_R	pTc	T_R	G	Tabular Z	Corrected Z	Brown F_z	CNGA F_{pv}	Katz F_z
A	674	0.79	382	1.36	0.691	0.90	0.895	1.056	1.060	1.062
A′	724	0.69	405	1.283	0.731	0.89	0.885	1.062	1.070	1.071

(Continued on Page 238)

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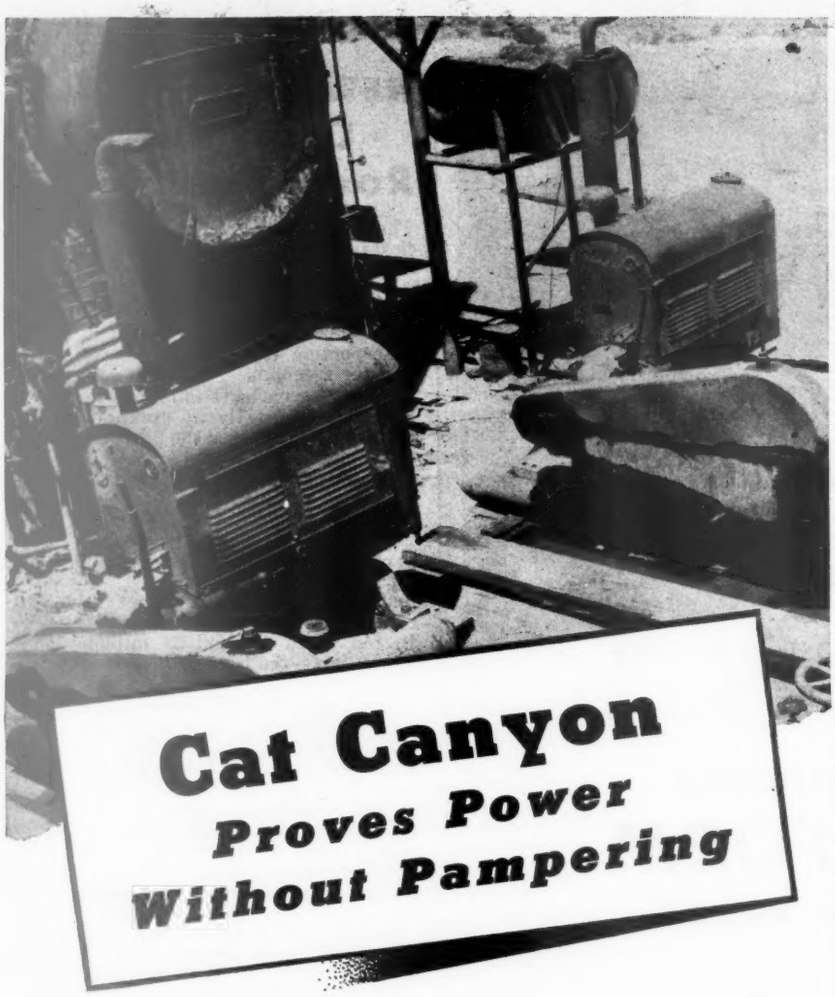

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(Continued from Page 234)

Column "Corrected Z" has the correction suggested by Dr. Brown, in which we subtracted 0.005 from tabular value for methane because this is a mixed gas at 500-lb. pressure. Values on Brown's graph cannot be read very closely at the points mentioned, but they suggest an increase in F_g of 0.006 due to presence of 8 per cent hydrogen sulphide, gravity being increased at the same time. Column CNGA F_{pv} merely accepts the increased gravity due to contamination with hydrogen sulphide and shows an increase in F_{pv} of 0.01 due to presence of 8 per cent hydrogen sulphide. Column Katz F_g likewise takes into account only specific gravity and does not recognize cause of increase.

In view of the reasonably close results in the last 3 columns, we appear justified in recommending specific gravity as a sufficient criterion of F_{pv} for any Turner Valley gas when used in Fig. 2 or its counterpart, the CNGA tables.

● **Other implications.** Pending a specific gravity determination of gas from any well, it is customary to assume a gravity based on determinations made on gas from neighboring wells.

Suppose a gravity of 0.70 is assumed, and later it is found that the gas is exceptionally high in hydrogen sulphide, say 8 per cent higher than in the measured gas, and for that reason the specific gravity is actually 0.74.

Then if the gas is metered at 500 lb. per sq. in. and 40°F., F_{pv} must be corrected from 1.073 to 1.085, an increase of 1.2 per cent. But the gravity factor (F_g) at the same time must be reduced 2.7 per cent. The two corrections tend to offset each other with the net result that the first computations overstated gas production by about 1.5 per cent.

If, however, the gas is metered at only 50 lb. per sq. in. and 40°F., F_{pv} will scarcely be changed from an original estimate of 1.005, the change being of the order of a fraction of a tenth of 1 per cent, whereas the gravity factor remains 2.7 per cent in error with overstatement of gas production in the original computations.

As hydrogen sulphide in high concenration may reach the dew point at conditions under which specific gravity determinations are made, special precautions may be necessary to make sure that specific gravity determinations truly represent flowing conditions.

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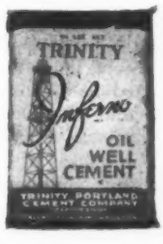

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URANIUM—SOURCE OF ATOMIC ENERGY

By **GEORGE E. KIDD,*** Magnolia Petroleum Company

THE now famous Manhattan project in accomplishing its military objective of producing the atomic bomb has simultaneously developed manufacturing techniques and plants that will make atomic energy available, perhaps within the next decade, to the specialized needs of industry and ultimately to the community at large.

EXCLUSIVE

Although much information of consuming interest to the engineer is still covered by the security black-out, the Smyth report[1] covers broadly the principles, the techniques, and the plants involved in the production of fissionable material from uranium. It is a story with which every engineer should be familiar. In this brief article the writer, himself an engineer, attempts, not to add to the information currently available but to lift out and explain in engineering language those facts that are of most significance to the man who requires only general orientation.

● **Uranium availability.** Uranium is present in the earth's crust to the extent of about four parts per million. It is found principally as oxides in pitchblende and carnotite, workable deposits of which are known to exist in practically every political sub-division of the world. On the North American continent uranium is found principally in Canada near the Great Bear Lake and in Colorado and Utah. Presumably, the Canadian source provided the major portion of the uranium ore for the Manhattan Project inasmuch as the company concerned had considerable mining facilities and a refinery in operation in 1938 that was capable of handling annually in excess of 8,000 to 10,000 tons of uranium compounds.[2]

There is said to be sufficient uranium in sight to satisfy all estimated needs for the next 200 years. This prediction is probably akin in accuracy to those that we frequently see published on the depletion of petroleum resources.

● **Uranium isotopes.** Although uranium by definition and by chemical behavior is an element, from the physical standpoint it can be separated into three distinct forms or isotopes, two of which are of profound importance to the nuclear physicist.

Fig. 1 presents the isotopes graphically. In order of abundance they are Uranium 238, Uranium 235, and Uranium 234 (hereafter abbreviated U-238, U-235, and U-234, respectively). As may be seen from the simplified presentation of the atomic structures, all forms have 92 negatively charged electrons rotating on well defined orbits (shown as a single circle) about the nucleus. Only in the nuclei are there differences and these are in the number of neutrons associated with the 92 positively charged protons.

Although the electrons are significant in chemical reactions, we learn in this case the unhappy news that all forms have 92 electrons. We cannot separate the uranium isotopes by chemical means, therefore, so we will dismiss them from our discussion as atomic "light-weights" and concentrate thereafter on the protons and neutrons forming the heavy nuclei.

● **Energy from nuclear fission.** Much work, both theoretical and experimental by physicists the world over, has established the fact that the old principles of conservation of energy and of mass are not, *on the atomic level*, two separate laws, but only a partial statement of the basic and single law that energy and mass are equivalent. Einstein, who first started this equivalence, expressed it in the equation form as follows:

$$E = mC^2$$

in which "E" is the kinetic energy made available whenever "m," the mass of any material, is annihilated. Conversely, the absorption of kinetic energy "E" by an atomic system will be accompanied by a gain in mass "m." The constant "C" is the velocity of light.

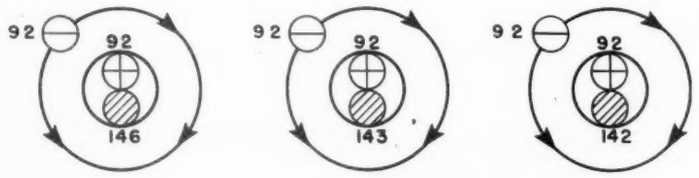
So great is the value of the constant "C" (186,330 miles per second in vacuo) that even relatively small changes in mass are accompanied by an immense energy release or absorption. Thus, the complete annihilation of *one pound* of any material would release in excess of *10 billion kw-hr.* of energy. This is equivalent to about 60 per cent of the peak monthly production of the entire U. S. electric power industry.

For reasons that are not yet fully understood, but have to do with the differences in the internal arrangement of the two nuclei, U-235 is the only isotope that can be fissioned to provide practical amounts of energy. U-238 undergoes occasional fission, but it is mainly just so much dead-weight that must be cut away before the U-235 can be concentrated in usable form.

The U-238 need not be wasted for, fortunately, there is available a nuclear reaction between neutrons and U-238 by means of which the U-238 is transmuted to another element, plutonium (aggreviated Pu), one isotope of which is also fissionable. Thus both U-235 and U-238 become sources of atomic energy.

At this point it is proper to consider the mechanism by which fission of U-235 occurs and to discuss some of the associated results. Fig. 2 will serve to illustrate the step-wise progress of the fission reaction. In step 1, a "thermal" or "slow" neutron, that is, a neutron moving at the speed of agitation of gas molecules at room temperature, is about to strike the U-235 nucleus. The impact and addition of one neutron so disturbs the internal arrangement of the nucleus that a highly unstable structure U-236 exists momen-

FIGURE 1.- URANIUM ISOTOPES.



ISOTOPE	U-238	U-235	U-234
RELATIVE ABUNDANCE	140	1	NEGLIGIBLE.

SYMBOL	PARTICLE NAME	RELATIVE WEIGHT (MASS)	ELECTRIC CHARGE
⊖	ELECTRON	1/1840	MINUS 1
⊕	PROTON	1	PLUS 1
▨	NEUTRON	1	ZERO

[1] A general account of the development of methods of using atomic energy for military purposes under the auspices of the United States Government, 1940-1945. H. D. Smyth.

[2] See Volume 50, "The Mineral Industry During 1941," McGraw-Hill Book Company.

*George E. Kidd has an international background having been born in the Transvaal, South Africa, and educated in England, Canada, and the United States. Upon graduation in 1929 from Oregon State College, Kidd was appointed a graduate assistant at Mason Laboratory, Yale University. He received his M.S. in mechanical engineering in 1930 and became associated with du Pont. In 1941 Kidd joined Magnolia as chief of the Field Research Department's Design Section. During late 1943 and early 1944 Kidd was loaned to the Metallurgical Laboratory, Chicago, on an assignment for atomic energy program.

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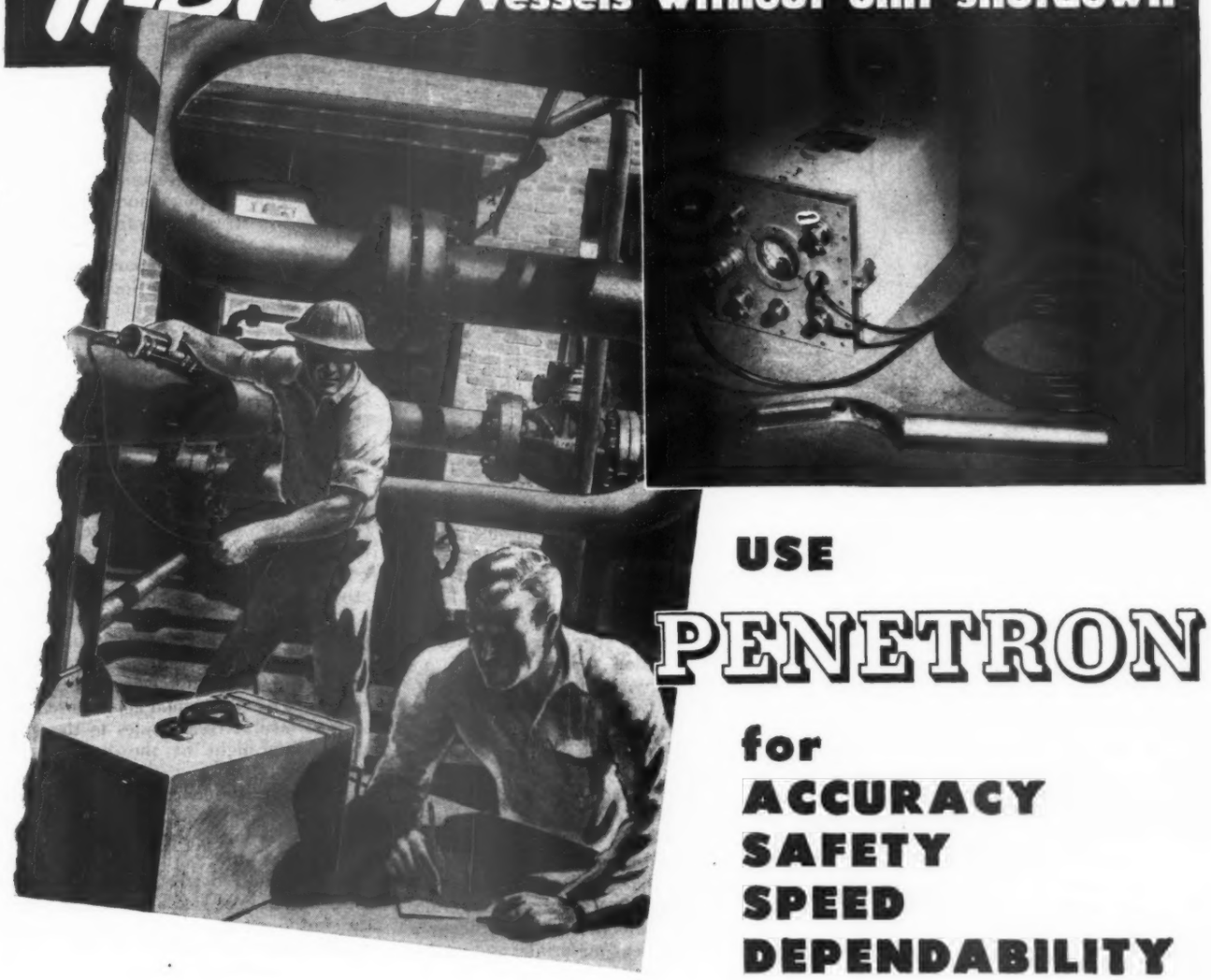

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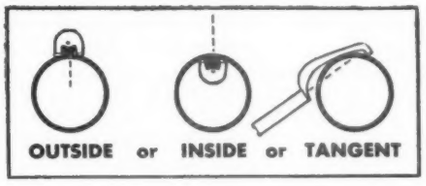

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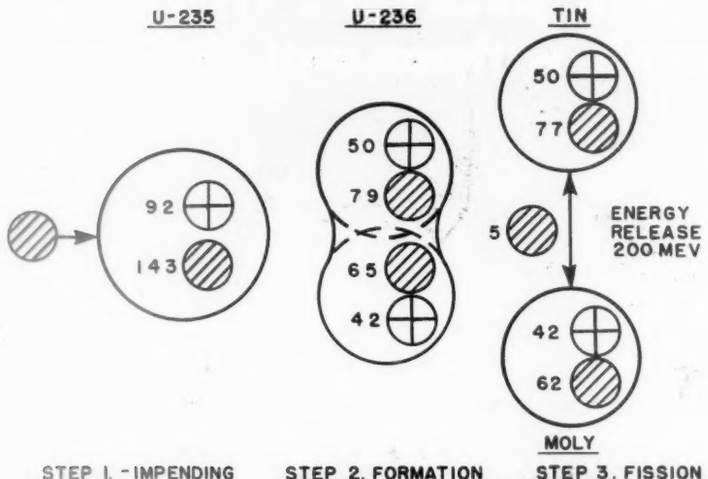
FIGURE 2 - FISSION OF U - 235.



tarily and then proceeds to disrupt into two nuclei of lower atomic numbers and smaller total mass than the affected U-235. This condition is shown by Step 3. The two nuclei are unstable isotopes of tin and molybdenum. These are chosen merely by way of illustration. Actually fission of U-235 results in the simultaneous production of a relatively large number of "pairs" of atoms similar chemically to elements near the center of the Periodic Table.

More significant than the actual identities of the resultant nuclei is that:

1. An energy release of some 200 million electron volts (about 10^{-17} kw-hr.) has taken place due to the fact that the total mass of the fission products is less than the mass of U-235 by about 0.1 per cent.
2. A number of "free" neutrons have been produced.
3. The newly produced nuclei are radioactive.

Of these effects, the production of "free" neutrons is by far the most important, for under properly selected conditions these neutrons are available to initiate fission in other U-235 nuclei and thus bring about the continuing chain of reactions so essential to the practical production of power.

We cannot, however, overlook the fact that the new nuclei, produced as the result of U-235 fission, are radioactive. The radiations from these nuclei are many times stronger than those from the most powerful of present day X-ray apparatus. Hence, the equipment involved in nuclear fission must be adequately "shielded" by thick barriers to protect the operating personnel. The need for heavy and bulky shielding is one of the practical difficulties that will be in the way of using atomic power regardless of the size of the plant.

● **Critical size.** The mention of plant size introduces another concept with which we need to be familiar. In discussing the production of "free" neutrons the statement was made that "under properly selected conditions" these neutrons were available to initiate a continuing chain reaction in other U-235 nuclei. Left to its own devices, the "free" neutron has very little chance of returning at the proper speed or energy level to continue fission. It may escape from the uranium environment; it may be absorbed in the U-238 thus producing plutonium or it may be absorbed in the media that constitutes the uranium environment.

The competition for the "free" neutron is so intensive and the probability so small that it will survive either escape or absorption by a material other than U-235 that utmost care must be exercised in the purification of the uranium metal, in the selection and purification of the environment materials, and in the manner in which the uranium and its environment are assembled.

There is, however, for every combination of these factors a lower limit in the size of the atomic power plant. This lower limit is termed the "critical size" and is by definition the size of the uranium envelope for which the loss of neutrons by escape and by absorption in media other than U-235 just equals the number produced by U-235 fission. Obviously, if we are to have a going concern, the practical plant must exceed the "critical size" enough to permit *at least one of every generation of neutrons to return and carry on the fission of U-235.* Means of achieving this result will be discussed later in connection with the production of plutonium.

● **The production of fissionable material.** The plants installed by the Manhattan Project for the production of fissionable material can be divided into two general classifications:

1. Those producing U-235 by physical separation methods, and
2. Those producing plutonium by transmutation of U-238.

The separation plants are at Oak Ridge, Tennessee, whereas plutonium production is carried out at Hanford, Washington. A brief discussion of the principles and type of equipment embodied in these plants will be of interest and may assist the reader in forming some idea of the route likely to be followed in the near future manufacture of fissionable material.

Two large scale separation plants were brought into production, namely the electro-magnetic and the gaseous diffusion plants. Both are extremely complex in arrangement but fortunately their operation depends upon principles that can be stated in straightforward and simple fashion.

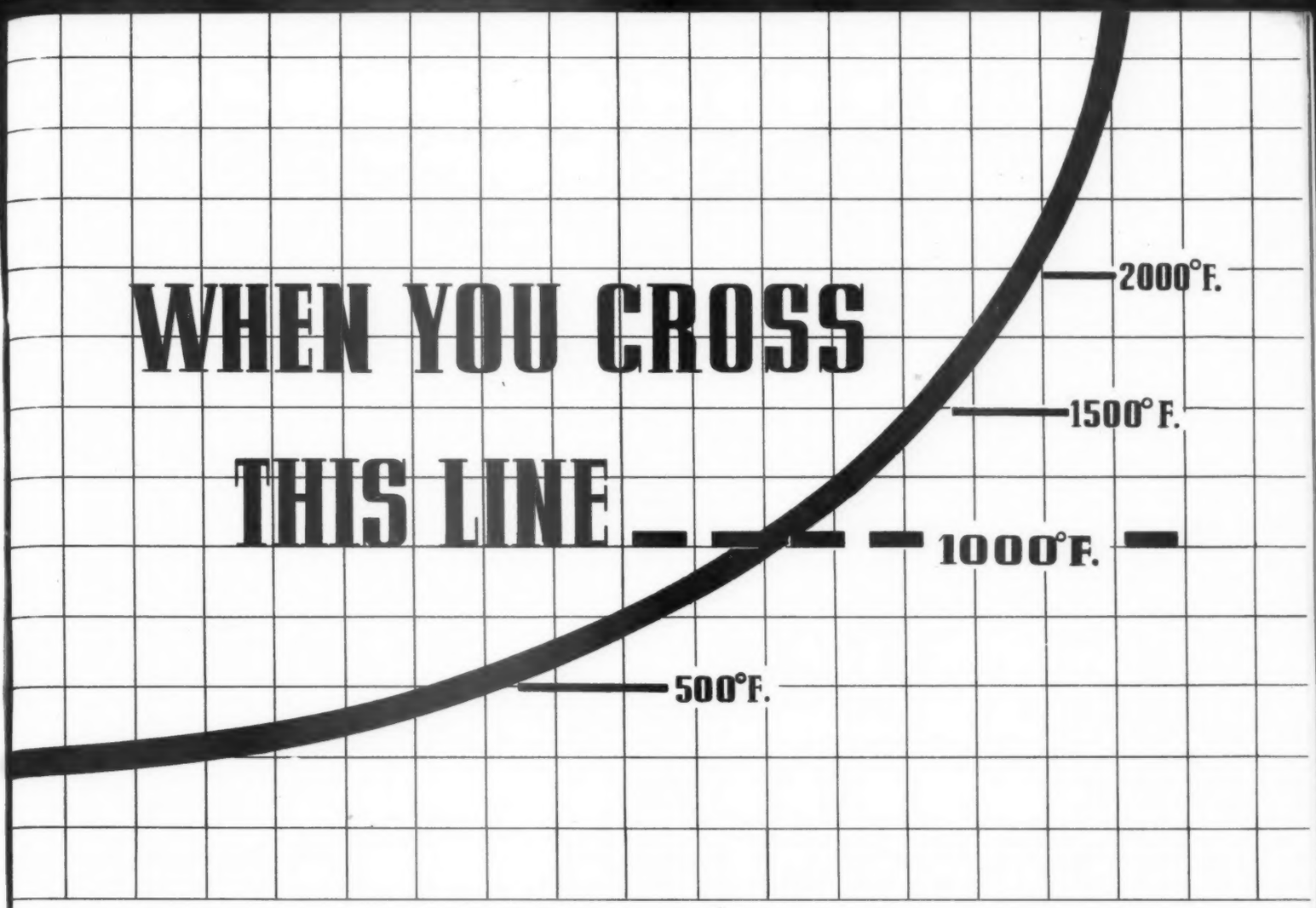
● **Electro-magnetic separation.** Fig. 3 illustrates the principle involved in the separation of U-235 from its more abundant isotope U-238. A uranium compound —uranium hexafluoride, UF_6, has been suggested as that now in use—is vaporized and introduced into a suitable electrical discharge tube. Here the hexafluoride molecules, which it must be remembered contain both U-235 and U-238 atoms, are broken and one or more electrons stripped from the atoms.

The now positively charged nuclei then pass into a high voltage electric field and are accelerated toward the negative side of the field. Some of the nuclei will be so fortunately disposed that they will pass through an escape slit in the negative plate and continue outward at high speed into an intense magnetic field generated by electro-magnets whose lines of force are at right-angles to the original line-of-flight of the hexafluoride nuclei.

Under the influence of the magnetic field, these nuclei no longer move in a straight line but now travel in semi-circular paths, the radii of which differ proportionately by the difference in the weight (mass) of U-235 and U-238. Thus the radius of the U-235 path will be smaller than that followed by the U-238. Properly positioned collectors will therefore retain the now separated nuclei.

In actual practice, the separation achieved in a single stage is not a sharp one and the material caught in the 235 collector is merely "enriched" in U-235. From the Smyth report it is evident that several stages are necessary and that a very considerable number of parallel production lines are employed, each consisting of "complicated electromagnetic devices requiring high vacuum, high voltages, and intense magnetic fields." Although the first and operating costs are undoubtedly high, the electromagnetic separation process should have the great advantage of flexibility.

● **Gaseous diffusion separation.** Fig. 4 illustrates the principle involved in the operation of the gaseous diffusion separation plant. The horizontal cylinder is divided into two compartments by a centrally placed porous barrier. A vaporized uranium compound—again the hexafluoride, UF_6, has been suggested as the most likely material—is introduced under pressure into the left or high-pressure side. To provide still more "driving force," the right side is placed under



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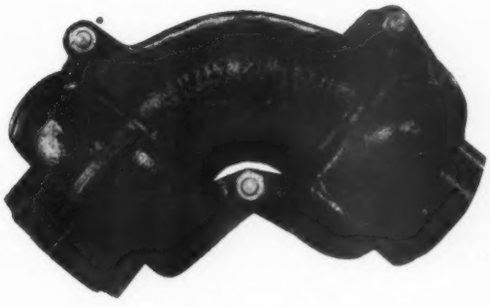

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vacuum. The hexafluoride will immediately begin to diffuse through the barrier, the openings or "pores" of which are microscopic in size.

The rate of diffusion of the two isotopes will differ because of the difference in atomic weights, the lighter U-235 passing through the barrier at a faster rate than the heavier U-238. Here again, a sharp separation is not achieved and the mixture withdrawn from the vacuum side is only enriched in U-235.

The production plant, therefore, consists of a large number of separation chambers. These are suitably interconnected and provided with the compressors, vacuum pumps, and controls necessary to maintain series operation of the enrichment train. The stage-to-stage exchange of enriched and exhausted mixtures is not unlike the interaction of vapor and liquid on the successive plates of a precision distillation tower but it is immensely complicated by the use of pressure as the driving force.

The Smyth report intimates that the number of major components of the plant, that is, the barrier vessels, the pumps and the compressors, etc., run into the thousands. The nature of the process and the type of equipment involved would appear to indicate that the gaseous diffusion plant would be less flexible and more costly to operate than its companion, the electro-magnetic separation plant.

● **Plutonium manufacture.** Plutonium preparation from U-238 requires an entirely different approach from those followed in achieving separation of U-235. Here we are interested in two nuclear reactions involving both the isotopes and neutrons. By means of the fission reaction (see Fig. 2) we are provided with a continuous source of neutrons some of which are available for use in the second reaction, that of the transmutation of U-238 to plutonium.

Fig. 5 shows the various steps involved in this reaction. In Step 1, a neutron of intermediate energy is about to strike the U-238 nucleus. This neutron is captured by the U-238 nucleus resulting in the emission of gamma rays and the formation of Uranium 239 (U-239), the condition depicted by Step 2. U-239 has a half-life of some 23 min., which is another way of saying that when 23 min. have elapsed 50 per cent of the U-239 originally present will have transmuted to yet another element neptunium (Np-239) by the emission of an electron from the nucleus. Just where the electron came from calls for explanation. This the physicist supplies by assuming that the neutron is not a fundamental sub-atomic particle but is actually a proton and an electron tightly bound together. Step 3 illustrates the procedure. Note that we have lost one neutron and gained one proton. Neptunium, having 93 protons, is therefore a new element derived from U-238.

Step 4 indicates that we have not yet completed the nuclear reaction. Neptunium, with a half-life of some 2.3 days, passes along, again with the loss of an electron, to plutonium (Pu-239).

FIGURE 3. THE ELECTRO-MAGNETIC SEPARATION METHOD.

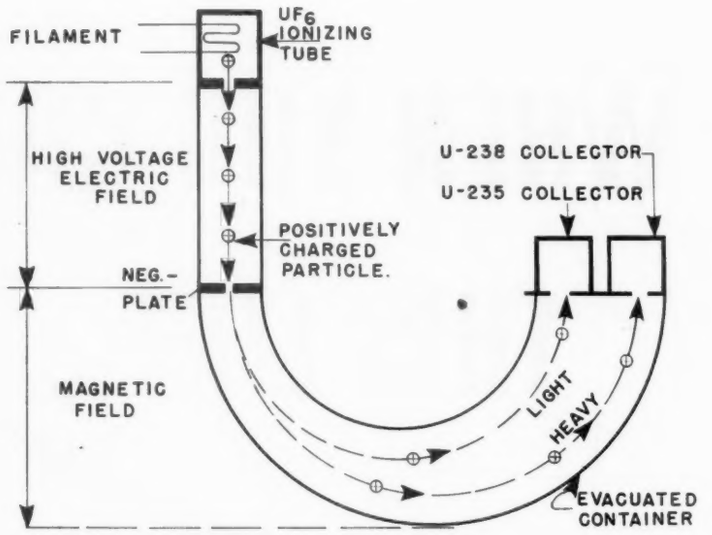
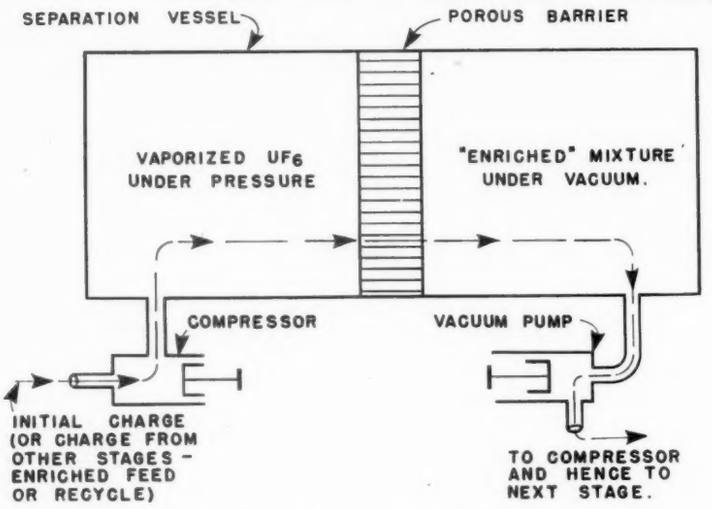


FIGURE 4. THE GASEOUS DIFFUSION SEPARATION METHOD.
(ONLY ONE STAGE ILLUSTRATED)


SEPARATION VESSEL
POROUS BARRIER
VAPORIZED UF_6 UNDER PRESSURE
"ENRICHED" MIXTURE UNDER VACUUM.
COMPRESSOR
VACUUM PUMP
INITIAL CHARGE (OR CHARGE FROM OTHER STAGES - ENRICHED FEED OR RECYCLE)
TO COMPRESSOR AND HENCE TO NEXT STAGE.

Plutonium is a relatively stable element. Because it is chemically different (94 electrons), it can be separated from the uranium isotopes and from the fission products. From the standpoint of fission it can be regarded as equivalent to U-235.

● **The plutonium pile.** The equipment in which the plutonium reaction is carried out is called a "pile." It is essentially a large block of graphite surrounded by a thick walled radioacticity absorbing structure of steel and reinforced concrete (Fig. 6A). The graphite is perforted with numerous holes that serve to retain the uranium metal, the control rods, and the cooling water piping.

The distribution of the uranium metal throughout the graphite is carefully controlled so as to obtain the most favorable conditions for neutron generation and use. The role of the graphite is to retain the neutrons within the uranium environment and to moderate their speed (reduce their energy) to the degree necessary for fission of U-235 or plutonium production from U-238. Fig. 6B serves to illustrate the slowing down process of two high speed neutrons resulting from the fission of a U-235 atom. Both neutrons collide elastically with numerous graphite atoms and at each collision impart part of their energy to the graphite. One (shown by the solid line) achieves so many collisions (about 200 are necessary) that it reaches the thermal energy level before it is directed back into the uranium where it causes fission of another U-235 nucleus. The other (shown by the broken line) does not undergo as many collisions but returns to the uranium at an intermediate energy level (resonance) such that it is captured by U-238 thus initiating the plutonium reaction.

Control of the pile operation is rendered simple by two very fortunate circumstances. The first is that nature has

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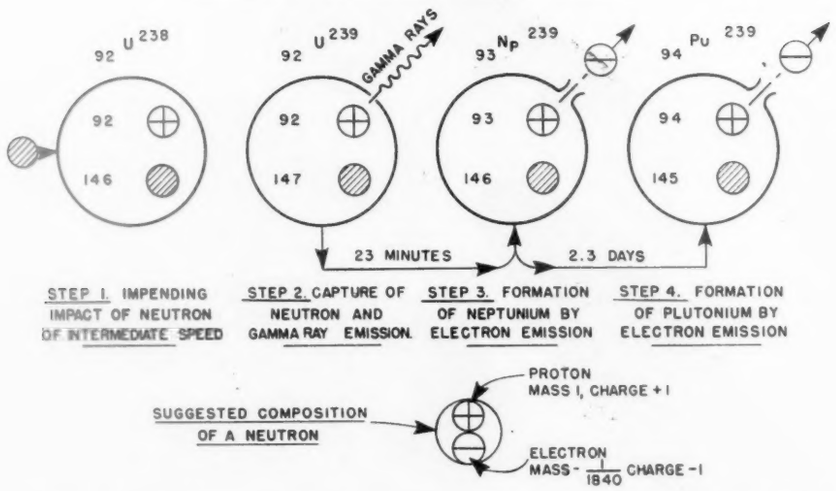
FIGURE 5. PLUTONIUM FROM U-238



supplied certain elements with an extremely high affinity for neutrons. Boron and cadmium are typical of such elements and can be used in the fabrication of control "rods." The second happy circumstance has to do with the timing of the departure of the neutrons generated by fission of U-235. The majority of the neutrons break away from the ruptured nucleus at fission but a few delay their departure for a short but significant period. This delay makes it possible to design an actuating mechanism that will have time to position properly the rods and thus hold the pile under control. To stop the pile, the control rods are pushed all the way in. Starting up is achieved by withdrawing the rods enough to allow a "stray" neutron (they abound in nature) to initiate fission. Production rate control is obtained by so positioning the rods that they absorb all neutrons not needed to hold the pile at the desired output level.

The flowsheet, Fig 6C, shows the steps involved in plutonium manufacture. It will not be discussed in detail but attention is drawn to the steps subsequent to reaction. Not all the uranium is utilized; economy of operation and other factors having to do with the balance between unreacted uranium, plutonium, and the radioactive by-products dictate the degree of its utilization. At the appropriate time, therefore, the metal is discharged from the pile and sent to the chemical separation plant. Here plutonium is separated from the unreacted uranium and by-products and is ready for use as a source of atomic energy.

The pile as a means of manufacturing fissionable material suffers from all the disadvantages associated with the handling of radioactive materials. It is, however, largely a static system and hence the operating and maintenance costs should be relatively small. Despite its bulk and the concentration of a large segment of production in one unit it would appear to have good flexibility.

● **The position of atomic energy as a fuel.** In the discussion of energy from nuclear fission it was stated that total annihilation of one pound of any material would be accompanied by an energy release in excess of 10 billion kw-hr. Uranium fission, as we have seen, does not result in complete annihiliation of the mass of the U-235 nucleus but there is a disappearance of about one one-thousandth part. Thus fission of one pound of U-235 (or of plutonium) releases somewhat over 10 million kw-hr. of energy. In terms of present day fuels this is equivalent to:

1. 1500 tons of coal, or
2. 40,000,000 cu. ft. of natural gas, or
3. 200,000 gal. of gasoline.

The fuel value of U-235 or plutonium in competition with existing fuels appears to be of the order indicated in Table 1 below.

TABLE 1—Competitive fuel value of U-235 or Pu.

Fuel	Unit cost, dollars	Per pound fuel value of U-235 or Pu, dollars
Coal	6.00 per ton	9,000
Fuel oil	0.05 per gal.	12,500
Natural gas	0.25 per M. cu. ft.	10,000
Gasoline	0.10 per gal.	26,000

There seems to be little doubt but that refined uranium metal could be obtained at about $10.00 per lb. At this figure, the U-235 content has a raw material cost of about $10 \times 140 = \$1400$ per lb.

Production and yield data are, of course, security secrets but reports have appeared in the press that place the military cost of fissionable material at $25,000 per lb. Just how accurate this figure is and what reduction, if any, can be achieved in near-future, peace-time production remains to be seen.

One thing, however, is perfectly obvious. The capital charges against investments of the order of 350 millions of dollars (the cost of the Hanford plant) will have a profound influence on the cost of the product.

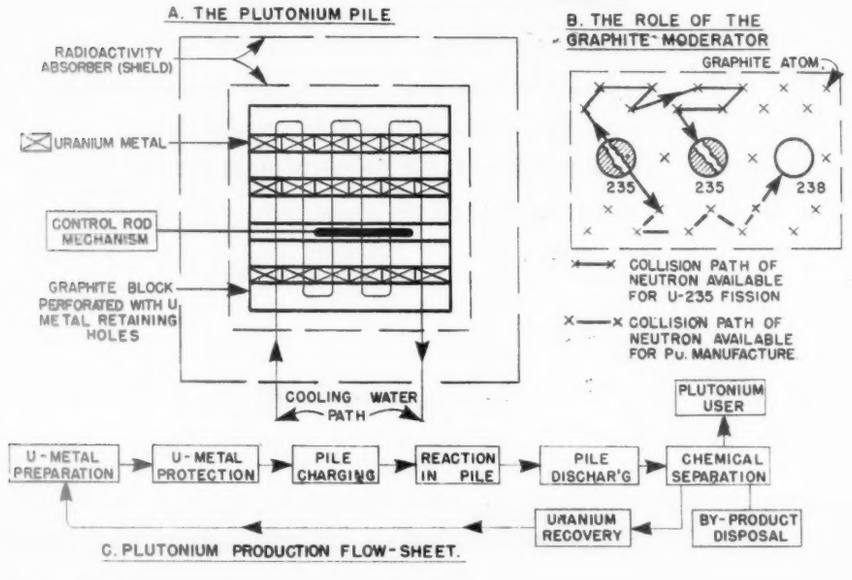
The government in its T.V.A. system accounting has charged off a large part of the investment in power dams to the intangibles of flood control, river channel improvement and navigation, etc., and has justified itself on grounds that deal broadly with the social development of the valley region.

If a similar line of reasoning were applied to the producing properties of the Manhattan Project, a major portion of the investment should be charged off to the prosecution of World War II. Such action might well place atomic fuel in a favorable competitive position even with coal.

We should not, however, look for the immediate and widespread use of atomic energy. Engineering, social, and economic problems of first magnitude must be solved before the benefits of this form of energy can be fully utilized.

Of these problems, that of engineering is undoubtedly the simplest and we can expect with some degree of real assurance to see atomic energy used, within the next decade, in such instances as do not involve radical changes to our present-day social and economic structure. Power plants remote from the usual fuels, mobile power units of large output, and the development of new cities are typical of the near-future uses of atomic energy. ★ ★ ★

FIGURE 6 - PLUTONIUM MANUFACTURE.



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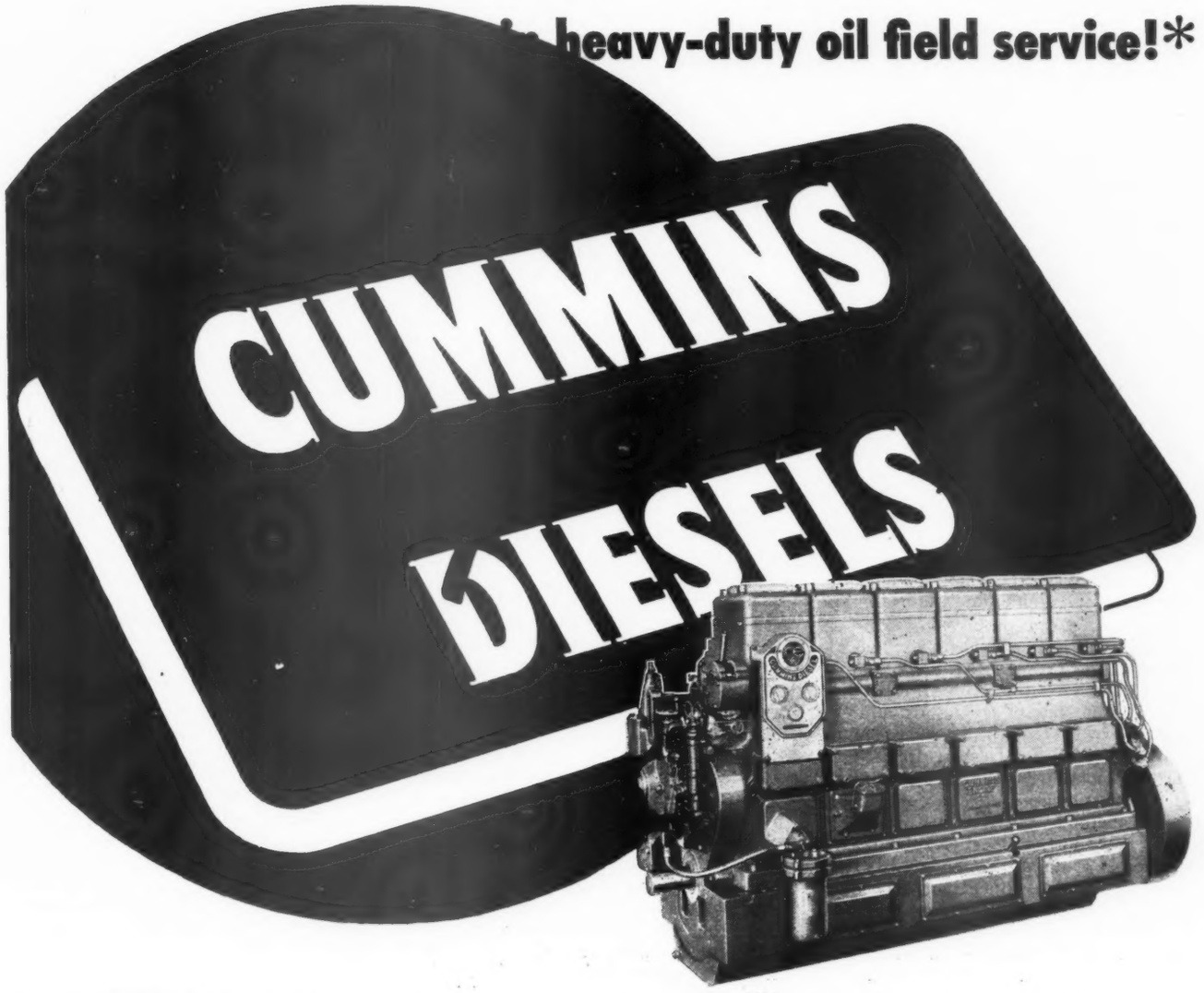

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RESEARCH AND THE "SHOE STRING" PRODUCER

By **F. R. COZZENS,** Equity Oil and Gas Company

EXCLUSIVE

No single development in recent years has given independent oil producers more encouragement than has the rapid expansion of production research. With research departments of various oil companies in almost every oil-producing state being staffed to extend laboratory and engineering aid, helpful changes in production methods can reasonably be expected in the near future, along with the introduction of more effective recovery mechanisms for operators with sufficient properties to benefit from them. Considering this prospect, there is keen speculation over the amount of oil-producing territory that can be brought into the secondary recovery program, and still keener speculation regarding what will happen to the 8,000 to 10,000 "shoestring" producers whose properties are too small, or otherwise unsuitable, for the application of present recovery methods.

Must the little fellow fold up and quit business when present methods fail to produce oil? Will his holdings be taken over through sub-contracts and operated as units by larger companies? Or, can he benefit by specially organized research aid, and still maintain his status as an independent producer? The problem affects approximately 85,000 stripper wells now nearing exhaustion by primary pumping, and the solution depends considerably upon the angle of approach.

The small producer has been, and always will be, an inventive individual. It was a member of this class (I. L. Dunn) who first put into effect the principle of air-drive in 1911. With only very meager knowledge of sand structure, Dunn started something that later became one of our most successful secondary oil recovery methods, but millions of barrels of oil were lost, properties ruined, and thousands of dollars squandered before adequate control of the principle became available. Most of the present methods of operating and reconditioning wells and equipment originated in small, and often remote, districts. These methods, too, are being used for the most part without text book guidance, but who can estimate the amount of oil, time, and effort that might be saved through a better understanding of the principles and their application. This creative ability is essential to the industry, and much of it must continue to come from the small producer who invents through necessity. He has the necessary background of practical field experience. He alone knows the peculiarities of the oil and gas fields in his locality; the history of the dry holes; the behavior of the producing wells, dating back to the wildcatting period. Methods and practices born in such environment will play an important role in determining future oil recovery plans, and when ways and means are found to aid local inventive ability with research guidance, many of the producer's problems can be solved.

Judging from past experience, initial contact between the oil producer and research worker is best carried out through a prearranged community meeting, held at some centrally located property in the district, all producers in an area being invited to attend. As the majority of producers own, or have access to, drilling equipment with coring bits, sand samples can be taken beforehand, and the analysis made a topic of discussion. Such analysis indicates not only the probable amount of recoverable oil in an area, but the methods and devices that will be necessary to bring it into the tanks. The producer does not expect to be shown miracles, nor does he expect to recover oil from territory that has already produced all that can be recovered economically. He wants the facts, good or bad, stripped as far as possible of technicalities, and phrased in oil-field language. Upon being convinced that research offers practical assistance, and not exploitation of the divining-rod variety, there will be cooperation, and usually the operator and his neighbors are quite willing to advance sufficient "dry-hole" money to keep the research service going. These community "get-togethers" may not solve any specific problems, but they should provide a working program for continuous mutual action.

If the sand under study is found adaptable to some type of pressuring, owners of small and scattered properties often can benefit through group action. Necessary equipment, such as tanks, pipe, well-fittings, etc., is pooled. Compressor units are bought in partnership, each partner's share of cost being based upon the size of his property and approximate number of wells. The plant may be operated in labor shifts by the producers themselves. Each individual supervises the pressuring of his own property, buying at his own expense any special accessories deemed necessary. He reserves the right to experiment, except when such experimental work interferes with neighboring properties. This latter detail must be ironed out through mutual discussion.

In localities where larger companies have pressuring plants already in operation, driving force (air or gas) can usually be purchased at a nominal rental fee. Both air and gas have been piped a distance of a mile or more to induction wells with very good results.

Sometimes small properties surrounding a large, well-equipped holding can benefit from pressuring by sub-contracting. The small producer retains ownership of his wells and property, and is paid a percentage of the oil increase made possible by pressuring service. Very isolated producers may solve a difficult pressuring problem with one of the light, portable compressors now available on the market. The practical independent can do much to assure the success of his pressuring project by cementing casing at the sand shoulder, and by installing packers in the sand column, so that driving force can be inducted into productive zones without waste. Further waste of pressure can also be prevented by a careful check-up on old, abandoned wells that have not been plugged properly. Many of these open holes can be closed successfully by exploding 25 to 50 lb. of dynamite or gelatin in some loose formation, as close as possible over the top of the pay sand; or a lye-and-water solution may be used for the purpose, being mixed in proportions of 25 lb. common lye to 1 bbl. of water. The objective in either method is to cause spoil, or cavings, in sufficient quantities to close the bore.

So far, only a small percentage of oil-bearing formations have been found adaptable to pressuring. This does not mean, however, that various other forms of secondary oil recovery cannot be practiced successfully. Large quantities of oil can still be recovered by the proper reconditioning of old wells, which means removal of accumulated sand and residue by the aid of cleaning-out tools, plus periodic cleanings with carbide, lye, or other chemicals, for removal of paraffin and sludge.

A very effective aid in reconditioning work is a newly-patented well washer that connects on the tools between the stem and the bit. Being of piston design, fluid is drawn into the barrel or chamber with each upstroke of the tools and discharged with considerable force against the sidewalls of the well on the downstroke. The result is a more successful clean-out job, and marked savings in both labor and time.

Old wells often may be drilled to deeper pays without reaming or increasing the diameter of the bore, or they may be punctured to exploit stray, or freak sands that may have been found and cased off in the original drilling. Geological research could do independent producers a splendid service by charting and analyzing the more prominent of these stray oil-bearing forma-

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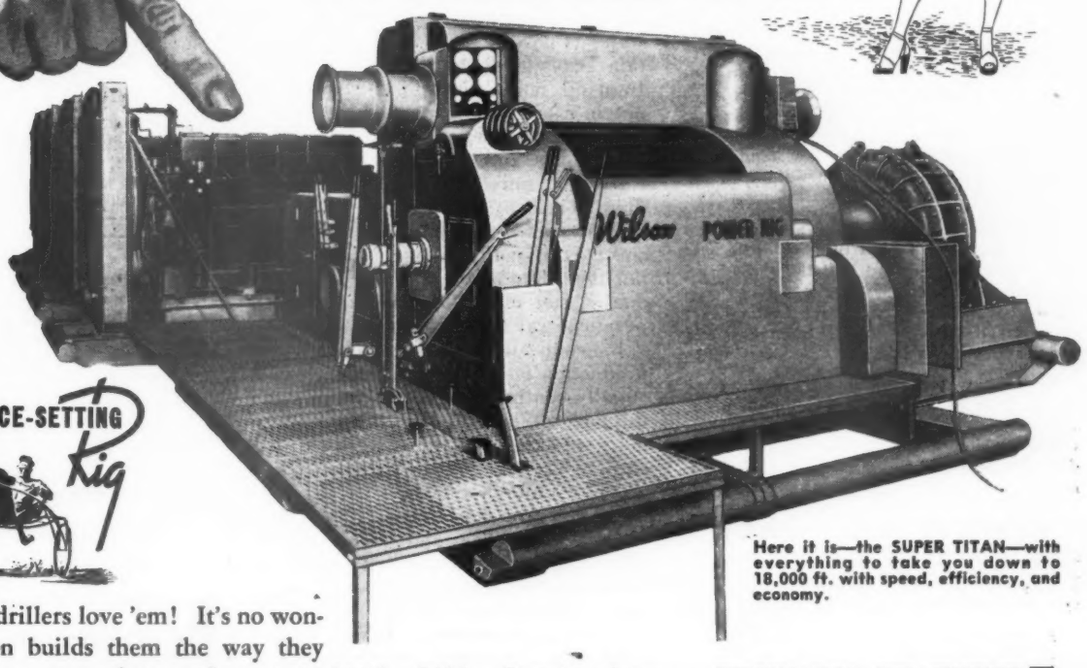

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WELL WATER SYSTEMS
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tions, of which a dozen or more are sometimes found on a single property. Such formations generally are localized and are often "spotty," but wells making 100 to 1000 bbl. daily in flush production have been found among this group in several areas of the eastern states.

Redrilling old fields, either for the opening of "strays" or established formations is an additional source of new oil, and in this work research has extended some valuable aid, especially in well-shooting practices. Newly drilled wells are now shot to obtain definite sand fracturing, instead of the old-fashioned chamber or reservoir; the bulk of the explosives being placed against the tight, and more restricted areas of sand. The practice results in greater oil drainage into the well, and saves considerable time in cleaning out. Core analysis of a sand shows, in some cases, the need for acid instead of explosives, and occasionally a combination of both.

Considerable attention is now being given to salt water and its relation to oil-bearing structures. From such studies and tests we can reasonably hope for more practical ways and means whereby salt water may be used as a medium for flooding oil into higher and more accessible sand areas. Such knowledge also will enable us to revive many oil-producing wells that have been "killed" by excessive quantities of salt water. Salt water is now utilized, especially in certain Texas fields, to replace fluid drawn from oil sands, the objective being to obtain a more uniform oil flow. Similar measures are being taken to induct natural gas, and gases created by chemical action, into depleted oil sands where fluid movement is sluggish. These measures are much too elaborate and expensive for the small producer to undertake, but they, like others, provide ideas and angles that may often be utilized in a practical way on small properties.

In connection with geological and production research work underground, equally continuous effort is being made through mechanical research to devise more effective well fittings, tools, and equipment for putting recommended measures into action. The small producer can now avail himself of a wealth of such knowledge, and under existing conditions no opportunity should be overlooked for making the best possible use of the service. Not only must there be better understanding of underground conditions, but better operating schedules, which lower cost of producing oil.

As natural oil production wanes, and secondary recovery measures become more necessary, the small independent will wisely keep his weather eye on research developments—sifting from the maze of experimental material, ideas, plans, and suggestions that can be used locally. Backed by a better understanding of the principles involved, and armed with the creative ability he has shown in the past, the small independent will retain his place in the industry and be most certain of his rightful share of recoverable oil. ★★★

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All along the line—from better drawworks for drilling, or pumps, either mechanical or hydraulic whichever the job calls for, right on into refinery equipment—Dresser Industries, Inc., is constantly engineering to reduce costs in the oil industry. If it's made by one of the Dresser Industries, it's—*First to be new—Last to wear out.*

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TAX PROBLEMS OF INDEPENDENT OPERATORS

It has been suggested that Mr. Thompson answer certain questions involving tax matters sent in by the readers. He has agreed to submit these questions to The Petroleum Accountants Society in Dallas for discussion, and to answer them in subsequent issues, should sufficient interest be expressed by the readers.

EXCLUSIVE

By SAM THOMPSON

Question:

Abbott purchased some land in fee for $5000, which he leased to Bostick for $1000 cash and an overriding royalty payable out of 1/16 of 7/8 working interest oil. Abbott also retained his 1/8 royalty interest. The following year, Abbott sold his override for $3000 to Chrisman. The following year oil was discovered on the property. Advise tax consequence?

Answer:

The $1000 is income representing cash received as lease bonus, and is subject to cost on statutory depletion whichever is the greater. (See Herring vs. Com. CTD 904 CB XIV-1, 303).

The sale of the overriding royalty is subject to Internal Revenue code section No. 117 (Capital Gains Provision). The date that Abbott procured the land in fee would govern the length of the holding period. (See A. G. K. Kleberg 2TC). Of course, it would be necessary to compute the cost applicable to the sale of the override, which could be accomplished in the following manner:

1. Value the property at date of acquisition as to minerals and surface area owned.
2. Obtain the expected recovery in barrels and place a value thereon.
3. The value of the royalty (1/8) would be one-eighth the expected recovery.
4. The override (1/16) would be 1/2 value of the royalty ($1/2 \times 1/8 = 1/16$).
5. The cost of the sale would then be the value of the override less the depletion allocable to the bonus.

For your ready reference, we are showing the references cited above:

(9012) William E. Herring, Petitioner, v. Commissioner of Internal Revenue. Eula Day Herring, Petitioner, v. Commissioner of Internal Revenue.

Supreme Court of the United States. Nos. 176 and 177. October Term, 1934. Decided December 3, 1934—(293 U. S. 322, 55 S. Ct. 322.)

On writs of certiorari to the United States Circuit Court of Appeals for the Fifth Circuit.

Percentage-of-income depletion in the case of oil and gas is allowable to a lessor based on bonus or advance royalty received in the year of execution of an oil lease, even though there was no production of oil in that year, no well having been drilled. "As to income tax liability in the year of termination of the lease, on account of bonus paid at the execution of the lease, if no mineral has then been extracted, we express no opinion."

CCH Dec. 13, 597. Alice G. K. Kleberg v. Commissioner. Docket No. 102254. 2 TC—, No. 129, Promulgated November 25, 1943.

1. (Sale of mineral interests: Taxability: Basis.) In 1933, petitioner owned in community a 3/32 right in all minerals in certain lands in Texas, acquired by her deceased husband in 1919 for services rendered to the then owner, Henrietta M. King. In September, 1933, petitioner individually and as executrix of her husband's estate, joined with the executors and trustees of the Henrietta M. King estate in a mineral lease to the Humble Oil and Refining Company. On September 26, 1933, petitioner, individually and as executrix, assigned to the representatives of the said King Estate the right to the royalties on said 3/32 interest under the Humble lease for a fixed sum, payable in two installments, i.e., 1933 and 1934. Held, the agreement of September 26, 1933, was a sale, entitling petitioner to the benefits of the capital gains provisions of the Revenue Act. Alice G. K. Kleberg, 43 B. T. A. 277 (December 11, 618), followed. Held, further, inasmuch as petitioner acquired her interest in the minerals in 1919 when the 3/32 interest was conveyed to her husband, her holding period for application of section 117, Revenue Act of 1934, was in excess of 10 years. ★ ★ ★

VISUALIZING ANNUAL REPORTS

EXCLUSIVE

By LYNE S. METCALFE

LEADING production and fiscal organizations in the petroleum industry have had much the same difficulties making the true significance of annual reports and financial statements understandable, as those experienced by other major industries. The two barriers to the end desired have been, first, the tendency of most people — employes and/or stockholders — to shun reading dry facts and figures in printed form; second, the inability of most people to grasp the true meaning of such figures in terms of company progress, efficient management.

Some of the oil companies have tried the plan of illustrating such printed reports and statements with sketches, photos, charts, etc., and this has helped. Just prior to the war, however, a large concern in the food field devised the novel idea of making a sound motion picture version of the annual report that proved to be a big success, but during the war such pictures were not feasible. Recently, however, the U. S. Steel Corporation has pointed the way with a movie clarifying its report and financial statements and other corporations are showing keen interest in the result. That many oil interests who wish to convey in clear and unmistakable terms the operations behind the figures, and the meaning of the totals, will find the movie the answer, is more than probable.

This U. S. Steel motion picture, produced by The Jam Handy Organization, is approximately two reels in length (screen time about 18 minutes). It is titled, "Behind the Annual Report."

The primary reason for producing a motion picture version of this report was to show the company's thousands of stockholders in clear and unmistakable terms, its financial and general condition, and then to convey to U. S. Steel's 300,000 rank and file employes, and 11,000 foremen, the same information. It is not a substitute for the regular printed version of the report but is supplementary to it.

As in this case, the oil company could inject specially made movie scenes of production and transport operations behind the financial report as a means of making the facts and figures more interesting, and to tie-in actual operations with management and disbursements. Numerous motion pictures techniques may be enlisted by the oil company as has been done by U. S. Steel, to take sets of formidable looking figures and giving them true significance. For instance, where animated techniques are enlisted to show the disbursement of the corporation's income dollar.

We all know that many employes have a notion that the employing company is owned by a few people who are "getting rich at it." In the case of the U. S. Steel movie, it is shown that the corporation is owned by a cross-section of American life and its invested savings.

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ACRE-FOOT RECOVERIES FROM OIL FIELDS

By **S. F. SHAW,** Consulting Mining and Petroleum Engineer

PART 2—Conclusion

EXCLUSIVE

● **Data on five old oil fields in New Mexico.** Only 5 fields in New Mexico are listed for which thicknesses are stated in which cumulative production is greater than 50 per cent of the estimated ultimate recovery. These 5 fields are listed in Table 12 and cover an area of 21,690 acres, averaging 78 ft. in thickness, from which cumulative recovery has been 136.6 million bbl., or 6300 bbl. per acre, or 81 bbl. per acre-foot. The ultimate recovery is estimated at 255.6 million bbl., or 11,800 bbl. per acre, or 151 bbl. per acre-foot. The Hobbs fields with a recovery of 104 million bbl. markedly influences the average in this list. Ultimate recovery of 1147 bbl. in limestone reservoirs does not seem correct, as computed for the Lynch field; revision of acreage or of thickness might change this figure.

The productive area for 64 fields in New Mexico is 254,660 acres, from which cumulative recovery has amounted to 381.8 million bbl., or 1490 bbl. per acre. Ultimate recovery of these 64 fields is estimated at 963.8 million bbl., or 3780 bbl. per acre.

● **Production data on old fields in Oklahoma.** In Table 13 is presented a list of 40 of the older fields of Oklahoma for which thicknesses are stated. The total area is 53,170 acres, averaging 45.2 ft. in thickness, from which the cumulative production has amounted to 507.5 million bbl., or 9550 bbl. per acre, or 211 bbl. per acre-foot. Ultimate recovery is estimated for 18 of these fields and amounts to 523.8 million bbl., or 12,010 bbl. per acre, or 281 bbl. per acre-foot. The consistently high recovery from the Wilcox (Ordovician) sand fields is noteworthy.

The total productive area of Okla-

TABLE 12—Data on production of old fields in New Mexico. As of January 1, 1944.

No.	Field	Year discovered	Producing formation	Productive acres	Thickness, ft.	Cumulative, M. bbl.	Bbl. per acre	Bbl. per acre-ft.	Ultimate, M. bbl.	Bbl. per acre	Bbl. per acre-ft.
1	Artesia	1923	Yates, Queen, Grayburg	5,200	25	4,979	917	38	7,000	1,320	53
2	Cooper	1929	Seven Rivers	4,320	55	14,657	3,390	61	23,000	5,320	97
3	Hobbs	1928	San Andres	10,240	124	104,179	10,170	82	160,000	15,600	126
4	Jal	1927	Seven Rivers	1,400	31	6,488	4,630	150	9,200	6,570	212
5	Lynch	1929	Yates, Seven Rivers	440	17	6,265	14,300	841	8,600	19,500	1147
			Total	21,690	78	136,568	6,300	81	255,600	11,800	151
			Total for state, 64 fields	254,600		381,791	1,490		963,840	3,780	

TABLE 13—Data on production of old fields in Oklahoma. As of January 1, 1944.

No.	Field	Year discovered	Producing formation	Productive acres	Thickness, ft.	Cumulative, M. bbl.	Bbl. per acre	Bbl. per acre-ft.	Ultimate, M. bbl.	Bbl. per acre	Bbl. per acre-ft.
1	Adams	1935	Misener	320	15	1,832	5,720	381	4,000	12,500	833
2	Altus	1934	Granite wash	1,740	30	1,947	1,120	37	3,000	1,720	57
3	Bethel, N	1936	Cromwell	300	20	4,291	14,300	715	....	....	....
4	Billings, shallow	1917	Various	590	50	6,218	10,500	210	....	....	....
5	Bowlegs	1926	Various, mostly Wilcox	4,000	30	122,733	30,680	1023	136,900	34,250	1132
6	Burbank	1920	Layton, Burbank	24,665	60	211,770	8,590	143	254,400	10,310	172
7	Byars	1939	Layton, Viola	280	132	603	2,150	16	1,700	6,070	44
8	Cromwell, S	1937	Wapanucka, Cromwell, Wilcox	100	13	571	5,710	440	....	....	....
9	Davenport	1924	Various Penn	2,335	50	12,288	5,260	105	15,000	6,430	128
10	Earlsboro, S	1930	Calvin, Hunton, Wilcox	430	25	9,343	21,700	868	....	....	....
11	Ed Fox	1925	Pontotoc, Deese	270	30	885	3,240	108	....	....	....
12	Frederick, W	1937-1939		300	3	3,095	10,320	3440	4,600	15,330	5110
13	Gray	1932	Wanette, Hunton, Simpson	320	25	4,995	15,610	624	7,300	22,800	912
14	Grayson	1935	Simpson	530	20	2,215	4,180	209	3,100	5,850	292
15	Guthrie	1941	Bartlesville, 2nd Wilcox	620	34	2,567	4,140	128	8,400	13,550	398
16	Hasel	1938	Thurman, Boggy	330	12	540	1,640	137	....	....	....
17	Hobart	1939	Pontotoc, Conglomerate	500	16	1,421	2,850	178	2,400	4,800	300
18	Holdenville, N	1926	Cromwell	80	19	141	1,760	93	....	....	....
19	Jones	1939	Cleveland	250	12	183	730	61	....	....	....
20	King, W	1939	Hunton	100	25	232	2,320	93	....	....	....
21	Knox	1924	Pontotoc	1,990	15	16,042	8,060	537	19,700	9,900	660
22	Konawa, W	1938	Boggy, Calvin	220	17	708	3,220	188	....	....	....
23	Lamont	1937	Wilcox	60	10	789	13,150	1315	789	13,150	1315
24	Little River, N	1941	Hunton, Dolomite, Wilcox	220	7	425	1,930	276	....	....	....
25	Maud	1928	Misener, Hunton, Simpson	1,980	10	12,424	6,270	627	13,970	7,020	702
26	Naval Reserve, S	1938	Simpson, Hominy	80	110	416	5,200	473	....	....	....
27	Oscar	1924	Glen	685	25	11,017	16,100	644	....	....	....
28	Otoe City	1930	Layton, Wilcox	240	30	354	1,470	390	1,700	7,070	236
29	Papoose	1923	Calvin, Gilcrease, Cromwell	2,815	10	22,197	7,900	790	23,800	8,450	845
30	Ramsey	1938-1940	1st Wilcox	630	27	8,175	12,950	480	23,000	36,500	1350
31	St. Louis, N	1941	Hunton	1,000	16	1,038	1,040	65	....	....	....
32	Seminole, W	1935	Calvin, Wilcox	500	30	14,265	28,330	944	....	....	....
33	Sasakwa Townsite	1933	Wilcox	175	3	2,501	14,250	4750	....	....	....
34	Shawnee, N	1937	Simpson	90	33	495	5,500	167	....	....	....
35	Stillwater	1935	Wilcox	130	6	536	4,120	687	....	....	....
36	Stroud	1923	Penn, Ordovician	590	50	9,223	15,600	312	....	....	....
37	Tatums	1927	Deese, Arbuckle	2,660	60	17,349	6,500	108	....	....	....
38	Trough, shallow	1937	Earlsboro	270	13	987	3,650	281	2,900	10,740	826
39	Wetley	1927	Hunton	675	165	575	850	5	....	....	....
40	King	1939	Hunton, Viola	100	42	142	1,420	338	....	....	....
			Total 40 fields—cumulative	53,170	45.2	507,428	9,550	211	....	....	....
			Total 18 fields—ultimate	43,595	42.8	....	....	....	523,760	12,010	281
			Total ultimate, Oklahoma (Oil and Gas Journal)	797,814	45.2	5,207,419	6,530	144	6,316,600	7,920	175

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homa is stated as 797,814 acres, with 5207.4 million bbl., or 6500 bbl. per acre. Ultimate recovery is estimated at 6317 million bbl., or 7920 bbl. per acre. Assuming an average of 45.2 ft. in thickness, which is the average of the 40 fields listed, the recovery per acre-foot would be 175 bbl.

In a state that has produced 5 billion bbl. of oil it would seem as though there should be a greater number of fields on which thicknesses of the producing formation could be obtained in these older areas. Perhaps such figures have been estimated, but are not available in published form.

● **Data on production from older East Texas Woodbine sands.** Table 14 presents acre-foot recoveries in the East Texas fault-line fields. The fields here listed are nearly depleted, the recovery having been about 94 per cent of the estimated ultimate recovery, and, so far as the Woodbine sand is concerned, presents probably as accurate a picture of any group of fields as can be obtained anywhere in the United States. For the most part these fields were closely spaced and production was at close to maximum capacity. The total area is 8150 acres averaging 42.1 ft. in thickness, and cumulative recovery has been 247.9 million bbl., or 30,400 bbl. per acre, or 722 bbl. per acre-foot. Ultimate recovery is estimated at 264.2 million bbl., or 32,420 bbl. per acre, or 770 bbl. per acre-foot.

Another set of 15 old fields in the East Texas area is listed in Table 15, the total area amounting to 24,055 acres, with average thickness of 23.3 ft., and cumulative recovery has amounted to 99.3 million bbl., or 4130 bbl. per acre, or 177 bbl. per acre-foot. Thickness of 4 of these fields for which ultimate recovery has been estimated and for which the total area is 19,455 acres, averages 26.8 ft., and ultimate recovery is estimated at 112.3 million bbl., or 5770 bbl. per acre, or 216 bbl. per acre-foot.

The total area comprised within the East Texas area, including East Texas, Hawkins, and Van fields, has a combined area of 336,964 acres, for which cumulative production has amounted to 2602.2 million bbl., or 7720 bbl. per acre, The ultimate recovery is estimated at 5917 million bbl., or 17,500 bbl. per acre.

● **Data on production in oil fields in the Edwards limestone, Balcones fault zone.** Three large fields are listed in Table 16, which produce from the Edwards limestone along the Balcones fault zone. The combined area is 5420 acres with average thickness of 36.9 ft., and cumulative production has amounted to 179.8 million bbl., or 33,200 bbl. per acre, or 900 bbl. per acre-foot. Ultimate recovery is estimated at 230.2 million bbl., or 42,170 bbl. per acre, or 1143 bbl. per acre-foot.

The estimated ultimate recovery of 1630 bbl. per acre-foot in the Salt Flat field seems very high, but the cavernous character of porosity may account for so large a recovery. Of course, thicknesses can be only an intelligent guess, and this should be considered when studying these figures.

Estimation of thickness is not satisfactory in this character of formation. Perhaps any figures on productive area are little more than good guesses. These fields, for the most part, were closely spaced and produced at close to maximum capacity.

● **Production data on older fields in the Upper Gulf Coast area of Texas.** Table 17 lists 19 old fields in the Upper Gulf Coast area of Texas developed before 1930, in nearly all of which fields the spacing was very close, and in which production was as close to maximum capacity as the operators were able to obtain. These 19 fields have a combined area of 14,215 acres, averaging 85.7 ft. in thickness[4, 5], and cumulative production has amounted to 957.2 million bbl., or 67,300 bbl. per acre, or 785 bbl. per acre-foot. Ultimate recovery is estimated at 1136 million bbl., or 80,000 bbl. per acre, or 933 bbl. per acre-foot.

Ultimate acre-foot recoveries of 3820 bbl. at Spindletop, 3417 bbl. at Orange, 2687 bbl. at Pierce Junction, and 3823 bbl. at Saratoga are clearly out of line with what seems possible to obtain, and

4. L. P. Teas. *Pet. Dev. & Tech.*, Vol. 107 (1934), p. 314.
5. Alexander Deussen. *Pet. Dev. & Tech.*, Vol. 118 (1936), p. 53.

TABLE 14—Data on production from old fields in Woodbine sand, East Texas. As of January 1, 1944.

No.	Field	Year discovered	Producing formation	Productive acres	Thickness, ft.	Cumulative, M. bbl.	Bbl. per acre	Bbl. per acre-ft.	Ultimate, M. bbl.	Bbl. per acre	Bbl. per acre-ft.
1	Powell	1923	Woodbine	2,600	40	112,249	43,200	1080	121,480	46,700	1167
2	Mexia	1912-1920	Woodbine	3,920	50	98,904	25,300	506	104,200	26,600	532
3	Wortham	1924	Woodbine	715	35	23,071	34,500	985	24,870	34,800	994
4	Currie	1921	Woodbine	475	20	6,976	14,650	732	6,976	14,700	735
5	Richland	1924	Woodbine	440	20	6,680	15,150	757	6,680	15,200	760
			Total	8,150	42.1	247,880	30,400	722	264,206	32,420	770

TABLE 15—Data on production from old fields in the East Texas area. As of January 1, 1944.

No.	Field	Year discovered	Producing formation	Productive acres	Thickness, ft.	Cumulative, M. bbl.	Bbl. per acre	Bbl. per acre-ft.	Ultimate, M. bbl.	Bbl. per acre	Bbl. per acre-ft.
1	Bazette	1939	Woodbine	100	15	236	2,360	157	....	....	....
2	Boggy Creek	1927	Woodbine	960	34	5,173	5,390	159	6,000	6,250	184
3	Bosque	1902	Basal, Walnut	2,500	3	116	46	15	....	....	....
4	Camp Hill	1935	Sub-Clarkville, Woodbine	200	5	289	1,450	290	....	....	....
5	Cedar Creek	1927	Woodbine	30	10	331	11,030	1103	....	....	....
6	Corsicana	1895	Nacatoch, Wolf City	6,710	32	14,718	2,190	69	18,300	2,730	85
7	Nigger Creek	1926	Woodbine	170	15	2,999	17,580	1172	....	....	....
8	Post Oak	1922	Buda	100	10	179	1,790	179	....	....	....
9	Potter	1905	Nacatoch, Tokio	980	15+	7,727	7,880	525	....	....	....
10	Rodessa	1935	Dees-Young	5,010	25	31,084	6,240	250	61,000	5,810	260
11	Rodessa	1936	Hill-Gloyd	1,885	20	9,485	5,030	251			
12	Rodessa	1937	Hill, Henderson, Gloyd	4,035	20	13,028	3,230	161			
13	Sulphur Bluff	1936	Paluxy	855	36	11,085	13,000	361	27,000	3,160	87
14	Trinity	1934	Carrizo	120	25	2,048	17,070	683	....	....	....
15	Witherspoon-McKie	1915	Nacatoch	400	19	810	2,050	108	....	....	....
			Total 15 fields—cumulative	24,055	23.3	99,308	4,130	177	....	....	....
			Total 4 fields—ultimate	19,455	26.8	....	....	....	112,300	5,770	216

TABLE 16—Data on production from old fields in Edwards lime, Balcones Fault Zone. As of January 1, 1944.

No.	Field	Year discovered	Producing formation	Productive acres	Thickness, ft.	Cumulative, M. bbl.	Bbl. per acre	Bbl. per acre-ft.	Ultimate, M. bbl.	Bbl. per acre	Bbl. per acre-ft.
1	Luling	1921	Edwards	2,200	50	80,023	36,370	727	97,060	44,100	882
2	Darst	1928	Edwards	1,920	30	55,416	28,890	963	80,000	44,700	1390
3	Salt Flat	1928	Edwards	1,300	25	44,341	34,100	1364	53,100	40,700	1630
			Total	5,420	36.9	179,780	33,200	900	230,160	42,170	1143
			Total East Texas area	336,964		2,602,203	7,720		5,917,000	17,500	

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some of the other figures for acre-foot recovery, although possible, are rather high. Estimation of thicknesses in these fields, several of which are on salt domes, are difficult to determine with any degree of satisfaction.

A second list of Texas Upper Gulf Coast fields is given in Table 18. These fields were nearly all developed since 1930 with wide spacing, and have been considerably restricted during much of their productive life. The combined area is 13,275 acres, with an average thickness of 21.9 ft. Cumulative production has amounted to 51.5 million bbl., averaging 3880 bbl. per acre, or 177 bbl. per acre-foot. Ultimate recovery is estimated at 102.8 million bbl., or 7740 bbl. per acre, or 353 bbl. per acre-foot.

The number of fields enumerated in the Upper Gulf Coast area is 188, covering a total of 187,944 acres from which cumulative recovery has amounted to 1648 million bbl., or 8770 bbl. per acre. Ultimate recovery is estimated at 4357 million bbl., or 23,200 bbl. per acre.

L. P. Teas presented data on thicknesses of Upper Gulf Coast fields in 1934[4]; these figures later were discussed by Alexander Deussen[5].

● **Data on production from Lower Gulf Coast fields of Texas.** A considerable number of fields has been developed along the Lower Gulf Coast of Texas, and in South Texas, during the last 10 or 15 years, but only a few fields of consequence have reached the stage of depletion where they can be considered as more than 50 per cent depleted. In Table 19 a list is given of 7 fields along the Lower Gulf Coast, aggregating 17,880 acres, and averaging 12.5 ft. in thickness. The cumulative production has amounted to 68.5 million bbl., or 3730 bbl. per acre, or 364 bbl. per acre-foot. Ultimate recovery from 5 of these fields covering 17,420 acres is estimated at 118.8 million bbl., or 6820 bbl. per acre, or 550 bbl. per acre-foot.

● **Production data from old fields in the South Texas area.** In Table 20 there are listed some 37 fields in the South Texas area, several of which are included in the Lower Gulf Coast area of the table found in *Petroleum Development and Technology*. These 37 fields

TABLE 17—Data on production from upper Gulf Coast fields developed before 1930. As of January 1, 1944.

No.	Field	Year discovered	Producing formation	Productive acres	Thickness, ft.	Cumulative, M. bbl.	Bbl. per acre	Bbl. per acre-ft.	Ultimate, M. bbl.	Bbl. per acre	Bbl. per acre-ft.
1	Humble	1904	Cap, Mio, Olig, Yegua, Eoc	2,350	±200	128,362	54,700	273	135,000	57,500	287
2	Spindletop	1901	Cap, Mio, Frio, Olig	500	69	127,393	254,780	3690	131,700	263,400	3820
3	Hull	1918	Cap, Mio, Olig, Yegua, Cook Mt.	875	63	97,952	112,000	1778	115,000	131,400	2086
4	West Columbia	1902	Mio, Frio	720	100±	93.347	129,600	1296	111,000	154,000	1541
5	Barbers Hill	1916	Cap, Mio, Olig	500	90	79,322	158,640	1763	95,000	190,000	2110
6	Sugarland	1928	Marg, Frio	1,200	80	33,098	27,580	345	90,000	75,000	937
7	Sour Lake	1902	Mio, Olig, Yegua	960	100	80,845	84,200	842	85,040	88,600	886
8	Goose Creek	1907	Plio, Mio, Olig	1,200	40	79,241	66,030	1651	81,000	67,500	1687
9	Raccoon Bend	1927	Jackson, Cockfield	1,624	30	28,077	17,290	578	51,000	31,400	1047
10	Batson	1903	Cap, Mio, Olig	650	30	40,739	62,670	2086	40,500	68,460	2282
11	Orange	1913	Mio, Frio	400	30	33,192	82,980	2766	41,000	102,500	3417
12	Pierce Junction	1921	Mio, Frio, Vicksburg	350	45	36,127	103,220	2294	42,320	120,900	2687
13	Saratoga	1901	Cap, Mio, Olig	500	17	30,215	60,430	3555	32,500	65,000	3823
14	High Island	1922	Mio	320	40	19,676	61,500	1537	26,000	81,250	2031
15	South Liberty	1925	Mio, Olig, Yegua	250	100	16,174	64,700	647	17,200	68,800	688
16	Blue Ridge	1919	Mio, Frio	400	55	12,196	30,490	555	14,000	35,000	636
17	Markham	1908	Cap, Mio	260	20	8,945	34,400	1720	8,525	32,800	1640
18	Damon Mound	1916	Mio, Frio	260	40	9,874	37,900	947	7,950	30,600	765
19	Fannett	1927	Mio, Frio	900	135	4,875	5,420	40	7,500	8,330	62
			Total	14,215	85.7	957,232	67,300	785	1,136,235	80,000	933

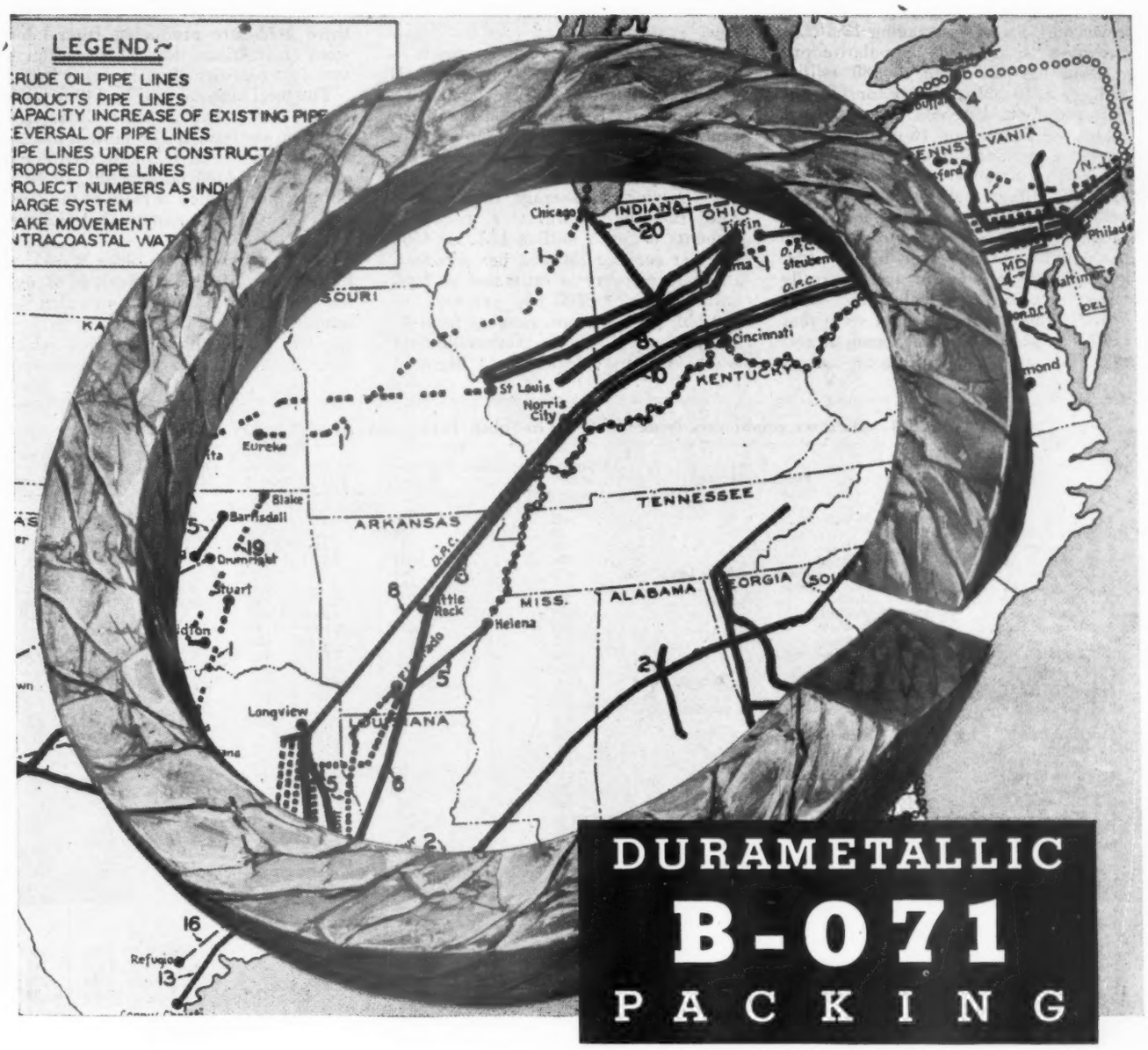
TABLE 18—Data on production from upper Gulf Coast fields developed since 1930. As of January 1, 1944.

No.	Field	Year discovered	Producing formation	Productive acres	Thickness, ft.	Cumulative, M. bbl.	Bbl. per acre	Bbl. per acre-ft.	Ultimate, M. bbl.	Bbl. per acre	Bbl. per acre-ft.
1	Angleton	1939	Frio, Olig	700	6	638	910	152	8,800	1,260	210
2	Arriola	1932	Mio, Frio	100	50	2,432	2,430	49	3,400	34,000	680
3	Bammel	1937	Cockfield	2,200	10	959	440	44	††1,180	537	54
4	Buckeye	1932	Frio	200	60	874	4,370	73	†960	4,900	82
5	Cheek	1937	Frio (abandoned 1944)	60	15	73	1,220	81	*70	1,170	78
6	Clay Creek	1928	Mio, Cockfield, Wilcox	340	120	4,769	14,030	117	7,000	20,600	172
7	Cleveland	1933	Cockfield, Wilcox	700	8	1,532	2,190	274	2,300	3,290	411
8	Clinton	1936	Mio, Cockfield	150	20	358	2,390	120	†720	4,800	240
9	Cotton Lake	1936	Frio	175	10	932	5,330	533	11,000	6,300	630
10	Hamman	1936	Frio	1,100	10	4,307	3,920	392	14,200	1,290	129
11	Hankamer	1929	Mio, Frio	400	29	6,674	16,680	575	10,200	25,500	879
12	Joe's Lake	1937	Wilcox	2,350	30	3,829	1,630	54	8,000	3,400	113
13	Livingston	1930	Cockfield	1,800	20	7,765	4,310	215	13,000	7,220	361
14	Lost Lake	1929	Frio, Olig	110	33	1,044	9,490	287	††1,220	11,090	336
15	Louise	1933	Frio	1,600	15	4,261	2,600	177	8,000	5,000	333
16	Mykawa	1929	Mio, Frio	350	30	4,766	12,190	406	5,800	16,570	552
17	Moore's	1926	Mio, Frio, Yegua	300	25	4,085	13,620	545	††5,350	17,830	713
18	Nash	1926	Mio, Frio (abandoned 1944)	260	60	1,665	6,400	107	††1,725	6,630	110
19	Palacios	1937	Frio	300	15	151	500	333	†380	1,270	85
20	Sandy Point	1937	Marginulina	80	3	346	4,320	1440	†480	6,000	2000
			Total	13,275	21.9	51,460	3,880	177	102,785	7,740	353
			Total upper Gulf Coast	187,944		1,648,067	8,770		4,356,533	23,200	

*Approximate. †Oil Weekly, March 16, 1942.

TABLE 19—Data on production from old fields in lower Gulf Coast area. As of January 1, 1944.

No.	Field	Year discovered	Producing formation	Productive acres	Thickness, ft.	Cumulative, M. bbl.	Bbl. per acre	Bbl. per acre-ft.	Ultimate, M. bbl.	Bbl. per acre	Bbl. per acre-ft.
1	Baldwin	1935	Catahoula	500	8	951	1,900	237	2,000	4,000	500
2	South Bentonville	1932	Frio, Vicksburg	220	11	540	2,450	223	....	....	....
3	Corpus Christi	1935	Miocene	1,500	10	6,759	4,500	450	6,759	4,500	450
4	Kingsville	1920	Mio, Catahoula	240	20	765	3,190	160	....	....	....
5	McCampbell	1936	Frio	6,200	9	12,210	1,970	219	26,000	4,190	466
6	Refugio	1922	Catahoula, Frio	8,500	15	41,471	4,880	325	69,000	8,100	540
7	Taft	1935	Catahoula, Heter	720	20	5,817	8,080	404	15,000	20,800	1040
			Total 7 fields—cumulative	17,880	12.5	68,513	3,730	364	....	....	....
			Total 5 fields—ultimate	17,420	12.4	....	....	....	118,759	6,820	550



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cover 58,175 acres, averaging 18.8 ft. in thickness, from which cumulative production has amounted to 188 million bbl., or 3230 bbl. per acre, or 172 bbl. per acre-foot. Ultimate recovery estimates are at hand on 16 of these fields having a combined area of 48,485 acres, for which ultimate recovery is estimated at 284.8 million bbl., or 5870 bbl. per acre, or 295 bbl. per acre-foot. The range of recovery varies from 38 bbl. per acre-foot at Somerset, to 1440 bbl. at Comitas. In view of the generally lower recoveries estimated for other fields in this group, it would seem that 1440 bbl. per acre-foot at Comitas, and 1023 bbl. at Piedre Lumbre are out of line.

● **Production data on older fields in West Texas.** In Table 21 are listed 23 older fields in the West Texas area, most of which have been depleted by 50 per cent or more, the average depletion of the combined list being about 54 per cent. The combined area covers 129,170 acres having an average thickness of 34.8 ft. The cumulative recovery amounts to 581.3 million bbl., or 4500 bbl. per acre, or 130 bbl. per acre-foot. Ultimate recovery is estimated at 1069 million bbl., or 8280 bbl. per acre, or 238 bbl. per acre-foot, ranging from 42 bbl. per acre-foot in the Netterville field to 680 bbl. in the Toborg field. Many of these fields are producing from Limestone formations for which ultimate acre-foot recovery often is rather low.

The total area covered by 140 fields in West Texas is 496,110 acres. Cumulative recovery has been 1377.8 million bbl., or 2770 bbl. per acre. Ultimate recovery is estimated at 4185 million bbl., or 8450 bbl. per acre, which is close to the average of the 23 fields enumerated in Table 21.

● **Production data on older Wyoming fields.** A list of 29 older fields in Wyoming is given in Table 22, for which the combined area is 60,680 acres, averaging 201 ft. in thickness, from which 494.9 million bbl. have been recovered,

TABLE 20—Data on production from old fields in South Texas area. As of January 1, 1944.

No.	Field	Year discovered	Producing formation	Productive acres	Thickness, ft.	Cumulative, M. bbl.	Bbl. per acre	Bbl. per acre-ft.	Ultimate, M. bbl.	Bbl. per acre	Bbl. per acre-ft.
1	Aviator	1922	Mirando	955	11	6,276	6,570	597	7,000	7,330	666
2	Barbacoas	1933	Frio	80	15	36	450	30	....	....	....
3	Blanchard	1939	Pettus	60	8	51	850	106	....	....	....
4	Caesar	1934	Cockfield	500	15	1,054	2,110	141	....	....	....
5	Calliham	1910	Carrizo, Mirando, Gov. Wells, Loma Novia	890	12	980	1,100	92	....	....	....
6	Charamousca	1935	Cole, McElroy	410	8	872	2,130	266	2,200	5,370	671
7	Comitas	1934	McElroy	750	10	1,769	2,360	236	10,800	14,400	1440
8	Cuellar	1927	McElroy	540	10	2,648	4,900	490	....	....	....
9	Diamond Half	1936	Cockfield	240	14	639	2,660	190	....	....	....
10	Dirks	1934	Cockfield	865	16	6,287	7,276	454	....	....	....
11	Eagle Hill	1933	Cole, Gov. Wells	550	10	1,886	3,430	343	4,000	7,270	727
12	El Tangue	1937	Frio	200	8	435	2,170	271	....	....	....
13	Gov. Wells	1928	Cole, Heter, Gov. Wells, Mirando, Yegua	8,500	17	32,750	3,850	226	77,000	9,060	533
14	Henne, Winch, Farres	1924	Mirando	720	16	3,215	4,470	280	....	....	....
15	Hoffman	1933	Hockley, Gov. Wells, Loma Novia Cockfield	3,400	17	10,409	3,060	180	25,000	7,350	432
16	Jacob	1926	Mirando, Pettus, Yegua	1,230	8	1,736	1,410	176	2,700	2,190	274
17	Kohler	1926	Cole, Gov. Wells, Mirando, Frio	360	14	692	1,920	137	....	....	....
18	Laurel	1932	Frio, Mirando, Cockfield	220	6	629	2,860	477	....	....	....
19	Loma Novia	1934	Loma Novia, Mirando	7,410	20	28,369	3,890	194	42,000	5,670	283
20	Lopes	1935	Mirando	3,450	18	13,405	3,880	216	22,000	6,380	354
21	Los Olmos	1925	Frio	240	17	657	2,740	161	....	....	....
22	McNeill	1934	Hockley	180	10	288	1,600	160	....	....	....
23	Mirando City	1921	McElroy, Cockfield	1,430	10	9,393	6,570	657	10,500	7,340	734
24	Mirando Valley	1921	McElroy, Mirando	1,000	9	1,562	1,562	174	2,200	2,200	244
25	Normanna	1930	Yegua	70	17	102	1,460	86	....	....	....
26	Peters	1933	Cole, Gov. Wells, Mirando	300	13	260	870	67	....	....	....
27	Pettus	1929	Cockfield	1,200	19	9,087	7,570	400	....	....	....
28	Piedre Lumbre	1935	Cole, Gov. Wells, Loma Novia	1,300	10	4,027	3,100	310	13,300	10,230	1023
29	Randado	1926	Cole	765	10	4,946	6,460	646	....	....	....
30	Ray	1935	Cockfield	420	15	1,615	3,840	256	....	....	....
31	Rio Grande	1932	Frio	200	8	448	2,240	280	....	....	....
32	Sam Fordyce	1934	Frio	1,600	16	7,589	4,740	296	9,100	5,680	355
33	Sarnosa	1932	Gov. Wells	690	15	2,782	4,030	269	4,000	5,800	387
34	Seven Sisters	1934	Frio	4,420	23	19,548	4,420	192	40,000	9,050	393
35	Somerset	1912	Taylor	11,390	30	11,151	978	33	13,000	1,140	38
36	Sweden	1937	Chernosky, Gov. Wells, Cockfield	1,500	12	268	179	15	....	....	....
37	Tesoro	1938	Pettus, Yegua	140	15	221	1,578	105	....	....	....
			Total 37 fields—cumulative	58,175	18.8	188,082	3,230	172	....	....	....
			Total 16 fields—ultimate	48,485	19.9	....	....	....	284,800	5,870	295
			Total South Texas, 238 fields	329,836		664,438	2,010		1,881,591	5,750	

TABLE 21—Data on production from old West Texas fields. As of January 1, 1944.

No.	Field	Year discovered	Producing formation	Productive acres	Thickness, ft.	Cumulative, M. bbl.	Bbl. per acre	Bbl. per acre-ft.	Ultimate, M. bbl.	Bbl. per acre	Bbl. per acre-ft.
1	Big Lake	1923	Queen, San Andres	3,300	58.2	70,804	21,470	368	129,300	39,200	673
2	Crane-Cowden	1926	Grayburg	2,160	10	5,547	2,570	257	6,500	3,010	301
3	Estes	1936	Yates	4,500	40	15,619	3,470	87	†58,000	12,890	322
4	Howard-Glasscock	1926	Yates, Seven Rivers, Grayburg, San Andres	13,500	24.6	109,112	8,090	328	163,000	12,070	489
5	Hurdle	1936	Grayburg	300	20	257	860	43	*300	1,000	50
6	Iatan-E. Howard	1926	Clearfork	7,300	50	17,721	2,430	48	35,000	4,790	96
7	Irion	1929	San Angelo	340	10	141	415	42	*168	465	46
8	Kermit	1928	Yates	15,240	40	30,971	2,030	51	51,800	3,400	85
9	McCamey	1925	Grayburg	19,200	30	57,633	3,000	100	103,400	5,380	179
10	McElroy	1926	Grayburg	14,000	40	133,179	9,510	238	226,000	16,140	404
11	McMillan	1927	Palo Pinto	210	12	960	4,570	381	*967	4,630	386
12	Netterville	1934	Yates	800	15	409	510	34	*500	625	42
13	North Ward	1929	Yates	10,000	40	27,230	2,720	68	71,800	7,180	179
14	Penwell	1930	San Andres	6,200	30	24,207	3,900	130	47,500	7,660	255
15	Scharboro	1927	Yates	2,000	10	7,467	3,730	373	12,800	6,400	640
16	Shipley	1928	Seven Rivers, Queen	2,700	60	6,140	2,280	38	30,200	11,200	187
17	Snyder	1935	San Angelo	1,740	50	2,553	1,470	29	5,400	3,100	62
18	South Ward	1930	Seven Rivers	10,500	40	28,005	2,670	67	55,900	5,320	133
19	Taylor-Link	1929	Yates, Queen, San Andres	2,500	25	8,249	3,300	132	15,900	6,360	254
20	Toborg	1928	Toborg	1,320	15	7,881	5,970	398	13,500	10,200	680
21	Westbrook	1921	Clear Fork	4,300	50	9,630	2,240	45	12,400	2,880	58
22	Wheat	1925	Delaware	4,060	7	9,208	2,270	324	13,000	3,200	457
23	World	1925	Grayburg	3,000	13	8,419	2,810	216	16,000	5,330	410
			Total	129,170	34.8	581,342	4,500	130	1,069,335	8,280	238
			Total West Texas, 140 fields	496,110		1,377,751	2,770		4,184,980	8,450	

*Oil weekly, May 4, 1942. †Estes-Dobbs.

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TABLE 22—Data on production from old fields in Wyoming. As of January 1, 1944.

No.	Field	Year discovered	Producing formation	Productive acres	Thickness, ft.	Cumulative, M. bbl.	Bbl. per acre	Bbl. per acre-ft.	Ultimate, M. bbl.	Bbl. per acre	Bbl. per acre-ft.
1	Badger Basin	1931	Frontier	300	49	545	1,820	37	....	....	....
2	Black Mt.	1925	Embar, Tensleep	300	135	295	980	8	....	....	....
3	Byron	1906	Embar, Tensleep	2,950	130	9,511	3,240	25	20,000	6,780	62
4	Cole Creek	1938	Shannon, Lakota	900	100	1,297	1,440	14	6,100	6,770	68
5	Dallas-Derby	1883	Embar, Tensleep	350	150	3,447	9,850	66	4,900	14,000	93
6	Dutton Creek	1927	Muddy	150	40	323	2,150	54	....	....	....
7	Elk Basin (light)	1915	Frontier	580	40	11,738	20,300	508	....	....	....
8	Ferris	1918	Mowry, Dakota	200	25	567	2,830	113	....	....	....
9	Frannie	1928	Tensleep	500	100	7,756	15,510	155	18,000	36,000	360
10	Garland	1930	Embar, Tensleep, Madison	2,000	400	5,408	2,700	7	10,000	5,000	13
11	Grass Creek	1914	Embar, Tensleep	2,000	450	32,088	16,040	35	50,900	25,450	56
12	Hamilton Dome	1913	Embar, Tensleep	2,000	130	6,487	3,240	25	15,000	7,500	59
13	Hidden Dome	1933	Frontier	50	15	392	7,840	523	....	....	....
14	Hudson	1914	Embar, Tensleep	340	185	2,412	7,080	38	3,000	8,820	47
15	La Barge	1923	Wasatch	950	150	8,651	9,010	60	15,000	15,790	105
16	Lost Soldier	1915	Tensleep	450	50	22,513	50,000	1000	49,000	108,800	2176
17	Mahoney Dome	1930	Tensleep	250	160	1,436	5,740	36	4,300	17,200	108
18	Maverick Springs	1921	Embar	1,400	50	1,818	1,290	26	8,100	5,780	116
19	Notches	1923	Tensleep	400	40	329	820	41	1,200	3,000	75
20	Oregon Basin	1927	Embar, Tensleep	10,000	150	25,740	2,570	17	82,500	8,250	55
21	Osage	1920	Muddy	10,000	10	5,193	519	52	7,700	770	77
22	Pilot Butte	1916	Niobrara, Tensleep	300	115	1,209	4,030	35	2,300	7,670	67
23	Quealy	1934	Muddy, Dakota	320	60	1,503	4,700	78	3,500	10,940	182
24	Rex Lake	1923	Dakota	200	50	295	1,480	30	....	....	....
25	Rock Creek	1918	Sundance, Tensleep, Madison	1,300	100	22,622	17,450	175	30,700	23,600	237
26	Salt Creek	1908	Frontier, Dakota, Lakota, Tensleep	21,450	335	308,391	14,400	43	365,000	17,000	51
27	South Caspar-Poison Spider	1920	Sundance, Tensleep	240	185	4,225	17,600	95	6,500	27,100	146
28	Warm Springs	1917	Embar	160	50	434	2,710	54	....	....	....
29	Werts	1921-1936	Tensleep	640	300	8,276	12,900	43	45,000	70,300	2343
			Total 29 fields—cumulative	60,680	201	494,901	8,160	41	....	....	....
			Total 21 fields—ultimate	58,740	206	....	....	....	748,700	12,750	60
			Total for state, 50 fields	83,720		599,257	7,150		1,216,800	14,531	

TABLE 23

Cumulative and estimated ultimate recovery from groups of old producing fields in the United States. As of January 1, 1944.

Fields, No.	Group	Acres	Thickness, ft.	Cumulative, M. bbl.	Bbl. per acre	Bbl. per acre-ft.	Fields, No.	Acres	Thickness, ft.	Ultimate, M. bbl.	Bbl. per acre	Bbl. per acre-ft.
5	Arkansas	39,120	30.7	480,380	12,280	400	5	39,120	30.7	528,000	13,500	440
9	California	56,130	260.8	2,968,770	52,890	206	9	56,130	260.8	3,512,000	62,600	241
12	Illinois	39,140	83.9	288,639	7,320	88	12	39,140	83.9	369,600	9,440	113
22	Kansas	87,740	48.9	373,792	4,260	87	22	87,740	48.9	439,600	5,000	102
10	North Louisiana	151,230	67.7	424,613	2,810	42	10	151,230	67.7	501,000	3,310	49
11	South Louisiana (old)	5,455	66.7	290,001	53,160	800	11	5,455	66.7	416,022	76,300	1144
10	South Louisiana (new)	8,365	50.7	175,713	21,000	414	10	8,365	50.7	245,100	29,300	578
14	Michigan	43,100	11.4	114,737	2,660	234	10	33,420	12.2	109,500	3,280	269
5	New Mexico	21,690	78.0	136,568	6,300	81	5	21,690	78.0	255,600	11,800	151
40	Oklahoma	53,170	45.2	507,528	9,550	211	18	43,595	42.8	523,760	12,010	281
15	East Texas	24,055	23.3	99,308	4,130	177	4	19,455	26.8	112,300	5,770	216
5	East Texas, Woodbine	8,150	42.1	247,880	30,400	722	5	8,150	42.1	264,206	32,420	770
3	Balcones Zone	5,420	36.9	179,780	33,200	900	3	5,420	36.9	230,160	42,170	1143
14	Upper Gulf Coast (old)	14,215	85.7	957,232	67,300	785	14	14,215	85.7	1,136,235	80,000	933
20	Upper Gulf Coast (newer)	13,275	21.9	51,460	3,880	77	20	13,275	21.9	102,785	7,740	353
7	Lower Gulf Coast	17,880	12.5	68,513	3,730	364	5	17,420	12.4	118,759	6,820	550
37	South Texas	58,175	18.8	188,082	3,230	172	16	48,485	19.9	284,800	5,870	295
23	West Texas	129,170	34.8	581,342	4,500	130	23	129,170	34.8	1,089,335	8,280	238
29	Wyoming	60,680	201.0	494,901	8,160	41	21	58,740	206.0	748,700	12,750	60
291	Total	836,160	71.4	8,629,239	10,320	144	223	800,215	73.5	10,967,462	13,700	187
2785	Total U. S.*	5,262,603		25,157,648	4,770					44,268,547	8,400	

*Omitting Alabama, Kentucky, Nebraska, New York, Ohio, Pennsylvania, West Virginia, and Panhandle.

or 8160 bbl. per acre, or 41 bbl. per acre-foot. Ultimate recovery of 21 of these fields having combined area of 58,740 acres is estimated at 748.7 million bbl., or 12,750 bbl. per acre, or 60 bbl. per acre-foot. Ultimate recovery ranges from 13 bbl. per acre-foot at Garland, to 2343 bbl. per acre-foot in the Wertz field. The recovery of 2343 bbl. per acre-foot in the Wertz field and 2176 bbl. from the Lost Soldier field are so very different from the general run of Wyoming fields as to make one suspect that productive thicknesses are determined in a different manner than in the other fields. The thicknesses in most of these Wyoming fields are so great as to lead one to surmise that unproductive footage is included.

A list of 50 fields is given in Wyoming in *Petroleum Development and Technology*, Vol. 155, having combined area of 83,720 acres, from which cumulative production has amounted to 599.3 million bbl. or 7150 bbl. per acre. Ultimate recovery is estimated at 1217 million bbl. or 14,530 bbl. per acre.

● **Data on combined production of all listed fields.** Table 23 gives a list of the various groups in Tables 3 to 22 for which the combined area is 836,160 acres, having average thickness of 71.4 ft. The cumulative recovery is 8629 million bbl. or 10,320 bbl. per acre, or 144 bbl. per acre-foot. Ultimate recovery from 800,215 acres averaging 73.5 ft. in thickness is 10,967 million bbl., or 13,700 bbl. per acre, or 187 bbl. per acre-foot.

The area of 2800 fields in the United States, which includes nearly all fields except those in Kentucky, Nebraska, New York, Ohio, Pennsylvania, West Virginia, and the Panhandle of Texas, for which figures on acreage are not available, aggregates 5,262,600 acres from which cumulative production has amounted to 25,157 million bbl., or 4770 bbl. per acre. Ultimate recovery from these fields is estimated at 44,268 million bbl., or 8400 bbl. per acre.

In view of the general average of 187 bbl. per acre-foot shown in Table 23 for fields in all parts of the United States, one may be led to wonder whether the much higher figures used for acre-foot recoveries for many of the newer and principal fields of the United States are not rather optimistic. If such is the case, the answer will be shown in downward revisions of ultimate recovery in these fields as they become depleted. Already some estimates have been revised downward, but it remains to be seen whether this will apply to many of the larger fields where, by reason of circumstances, it was necessary to make estimates by use of the volumetric method.

This is the second and last part of Mr. Shaw's article.

MACHINERY AND EQUIPMENT

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(1) *Immersion heater*

The American Instrument Company, Silver Spring, Maryland, announces a new automatic electric safety immersion heater for liquids. This heater and its automatic control, combined in one self-contained unit, is ideal for installation in domestic and industrial water tanks, drums, processing kettles, stills, sterilizers, crank cases, pipe lines, glue pots, etc., it is stated. It can be installed in any container where safe, automatic, economical, convenient, and dependable heat is required for heating liquids.

Once installed and set for the desired working temperature, it will function accurately without further attention.

The built-in safety control will limit the temperature rise of the heater and thus protect it against overheating and burning out should the liquid level fall and expose the heating element to air.

The heater can be easily and quickly screwed into the walls of a tank, drum, etc., through a 1-in. pipe fitting or reducer, and only 2 wires need be connected from the current supply to the heater. Two or more of these automatic heaters may be installed on one application and adjusted for step temperature control, or, where it is desirable to install more than one heater in the same vessel, the Aminco safety heater can be used to regulate one or more non-automatic heaters through a relay.

By merely turning an indicating screw, this heater can be set as desired from room temperature to 350°F. Thenceforth, the heater will continue to maintain the temperature of liquids within plus or minus 5°F.—a conservative rating.

The sheath of this heater cannot become electrically energized, thus there is no danger of the material becoming electrically charged.

A pilot light indicates when the heater is functioning.

These heaters are available with copper sheaths for heating water, or with steel sheaths for heating light oils, in wattage ratings of 250, 500, 750, and 1000.

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(2) *Quintuplex pumps*

Rated at 300 to 450 hp., depending upon its speed, a 6-in. stroke inverted quintuplex pump has been designed in response to a growing demand for the smooth performance of a quintuplex in this size, according to the Aldrich Pump Company, the manufacturer. Plunger diameters range from 2 to 5¼ in., working pressures from 700 to 5000 lb. per sq. in., and capacities from 60 to 850 gal. per min.

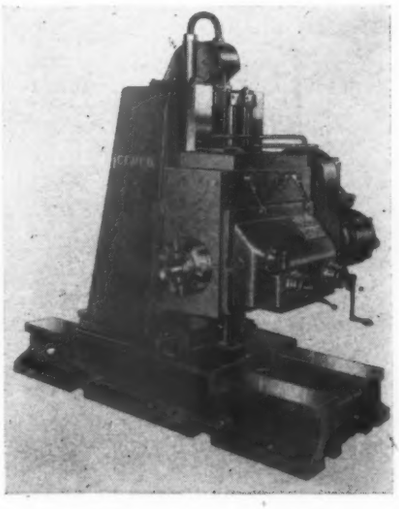
The Aldrich line of inverted quintuplex pumps now includes 6, 8, and 10-in. pumps requiring from 300 to 1000 hp.

(3) *Boring, facing machine*

The General Engineering and Manufacturing Company, St. Louis, Missouri, announces as the latest addition to its line of precision machinery, the boring and facing machine shown in the accompanying illustration.

The innumerable applications of this machine, often used in multiples, will be found in boring, facing, back facing, drilling, and tapping operations on surfaces of heavy cumbersome work pieces that may not be accessible to standard machine tools.

An outstanding feature of the Gemco boring and facing machine is the unusual mounting of the spindle housing, which provides for greater rigidity in facing, boring, and milling operations. Rigidity is obtained because the entire spindle housing, with its spindle nose of fixed position in relation to the bearing, 4.25 in., is advanced toward the work piece. This construction, by avoiding long overhang, greatly reduces vibration, increases permissible feed and depth of cut, and assures machining to very close limits with a resultant decrease in production time.



The machine may be used either as a stationary machine in a permanent position and the work piece brought to the machine, or as a portable machine, in which case it is taken to the work piece.

A retractable spindle supported by a fixed quill in the spindle housing is offered, at extra cost, as another feature in the Gemco boring and facing machine should it be used extensively for drilling operations.

The machine can also be modified and provided with automatic feed mechanism, to be used as a milling machine. For large boring or facing operations, back-facing of flanges, etc., a special face plate with tool block slide may be mounted on the head of the work spindle.

(4) *Mobile drilling rigs*

In recent years there has been a rapidly accelerating tendency in the direction of portability, not alone in the matter of derricks and drilling units, but in all the varied petroleum equipment and plants that are utilized in impermanent operations. This is merely a part of a greater and still more fundamental trend toward the ultimate in conservation and economy. In any highly competitive field, these factors are the ultimate criteria by which design engineers must gage the adequacy of their products.

In the middle of a war that was gobbling up incredible quantities of steel for mechanized equipment, and requiring the elimination of every non-essential use of metals, a substantial fillip was given to the development of mobile drilling units, for the expansion of this trend obviously promised a considerable saving in high-priority steel. The enlarged use of mobile drilling equipment offered the prospect of maintaining the maximum production of oil with the minimum sacrifice of steel, and since greater mobility was a firmly established trend that was unquestionably to be projected into the postwar years, equipment manufacturers really began to concentrate on the matter.

With the rationality of mobile units accepted, both from the standpoint of operational facility and comparative cost, there followed a sort of review of progress and a general effort to adapt, amend, and improve. The result is that masts, portable and semi-portable, mobile derricks, and completely mobile drilling assemblies, with all the essentials mounted on carriers, and movable as units by their own power, are now being manufactured extensively and are doing yeoman service in drilling and production programs.

In California, it may be be said that virtually all derricks are now mobile to some degree. It is rarely that a derrick is left standing over the hole when a well has been completed. The necessity for moving from one location to another has had, as might be expected, a salutary effect on design. It has been found desirable, for example, to strengthen the legs so that the moving might be contrived without further reinforcement. Also, with the gradual extension of completion depth, higher derricks with more base area are the order of the day, and this means greater weight, which in turn demands greater overall rigidity.

Wagner Morehouse, Inc., recently completed a series of four L-2 drilling units of unusual design, for special service in swampy territory in the Dutch East Indies. This model is a mobile unit in every sense of the word, completely unitized in all details and ideally constructed for safe, speedy, and economical operation. It is equipped with Athey traction for traveling over rugged and soggy terrain with the minimum of difficulty, and has incorporated in compact and convenient arrangement every significant piece of equipment and machinery that is required in a shallow drilling program.

The units are 62 ft. high, with a net hook load of 35 tons, and are designed for drilling to approximately 1500 ft. Power for the pumps (Gardner-Denver 5 in. by 8 in.) is derived from two 100-hp. Cummins diesels. A third Cummins diesel supplies power for the drawworks. A Martin-Decker weight indicator is permanently installed, with the diaphragm valve anchored to the top of the derrick, and an instrument panel so situated as to give full visibility to the driller at all times, and at the same time provide room to operate the controls. Other pieces of equipment in this highly interesting assembly are an Overstrom mud screen, National rotary table, McClatchie joint breakers, Gray swivel, Baash-Ross block, Shaffer well controls, Hamer plug valves and line blinds, and many other nationally known reputable items. Incidentally, all parts are numbered to facilitate assembly, and the unit is wired for light and power wherever they might be needed. It is also easily adaptable to servicing by merely removing the exclusively drilling equipment.

(5) *Safety flashlight*

Justrite Manufacturing Company, 2061 North Southport Avenue, Chicago, Illinois, manufacturers of safety products, announces a plastic safety flashlight equipped with the new Justrite Honeycomb lens. Designed as a working light for industry, the special lens provides a wide circular beam three times as large as the "spot" beam powered with the usual flashlight. It is reported that at a distance of 8 ft. this new unit covers an area about 3 ft. in diameter with a clear beam that lights the work area brightly and evenly. "Dark

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rings" and "spots" are thus eliminated.

The flashlight uses 3 standard flashlight cells approved for safety by the U. S. Bureau of Mines and the Underwriters' Laboratories (Class 1, Group D). It is stated that the compact design—with belt clip on side and carrying ring on bottom—permits ease in handling. The light is 5¾ in. high; 2¾ in. wide. Reflector is 2½ in. in diameter. Case is made of durable plastic molded in one piece and guaranteed against breakage in normal use. Reflector and lens ring are metal.

This 3-cell flashlight, known as Model No. 17-S, with wide Honeycomb lens or with the regular type "spot" lens, is now available for immediate delivery.

(6) *Mud gun equipment*

Patterson-Ballagh's latest contribution to the all important mud handling problem is the Patterson-Ballagh mud gun platform and assembly. Designed as a sturdy, rugged support for Patterson-Ballagh mud guns, this new item has been readily accepted by operators who heretofore have had to resort to makeshift or expensive arrangements for the support of mud guns, it is stated. The platform is made for the toughest jobs, will last indefinitely, and can be moved from job to job. The holes in each corner are used for fastening the base down. The complete assembly shown in photo consists of a Patterson-Ballagh mud gun, in this case the Muddler, the platform and the counterweight (also an accessory) shown on the handle. The platform or base is quickly and easily connected to the mud line and the mud gun by hammer unions. Patterson-Ballagh's other mud guns, codes Mufti and Midlean are interchangeable with the Muddler in this assembly. The high pressure valve shown in photo is not part of the assembly.

The counterweight is a 25-lb. cast-iron weight that slides on the handle and can be locked in any desired position. Its purpose is to act as a counterbalance where an extra length of discharge pipe has been added.

The assembly may be purchased as a complete unit, or the mud gun, platform, and counterweight are available separately. Stocks are maintained at the company's warehouses in Los Angeles and Houston.

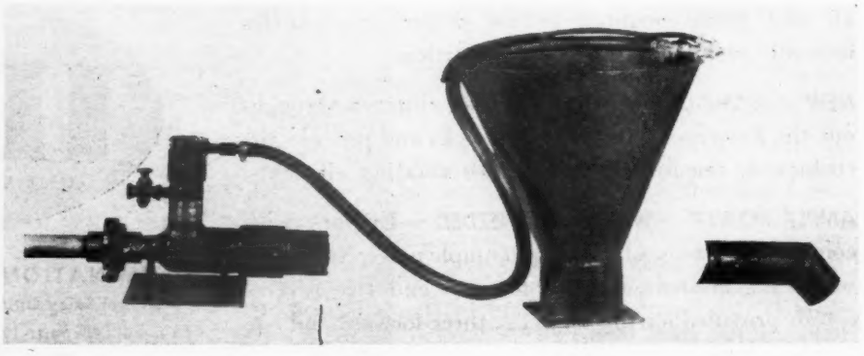
(7) *Muderator*

The Muderator, equipment for mixing drilling mud, is announced by Mid-Continent Supply Company, Fort Worth, Texas.

No extra accessories are needed to utilize the Muderator, it is pointed out by the manufacturer. The equipment mixes the mud entirely by means of a vacuum created by the passage of drilling mud from the circulating pump. Thus, there is no moving or complicated mechanism to get out of order.

The Muderator is set up on the rig by running a 2-in. bypass line from the circulating pump and connecting it to the 2-in. wing union on the Muderator. A 4-in exhaust line is then laid from the Muderator to the mud pit so that it will discharge into the pit near the pump suction.

The rate of intake of the dry mud is regulated by the control valve on the pick-up nozzle. To increase the intake of dry mud, the valve is opened wider on the pick-up nozzle.



PROTECTION

AGAINST SUDDEN PRESSURE INCREASES WITH EDWARD RELIEF VALVES

Economical Edward forged steel relief valves protect expensive equipment against sudden and dangerous pressure increases.

Widely used in power, chemical process, petroleum, hydraulic, marine and general industrial service, these relief valves are particularly suited for pump lines, drums, heat exchangers and unfired pressure vessels generally. Regularly available with either carbon or stainless steel springs, for water, steam, oil or vapor service.

Seat and ball disk are precision machined of EValloy stainless steel. The hardened stainless steel bearing plug gives point contact with the disk for quick and tight reseating after operation.

DIMENSIONS AND WEIGHTS—Fig. 141
Angle Relief Valve

SIZE	¼" & ⅜"	½"	¾"	1"	1¼"	1½"	2"
Center to End	1½	1⅞	2⅛	2⅜	2¾	3⅛	3¾
Center to Top	6½	7¾	9¾	10⅛	12⅜	14½	16¼
Weight—Lbs.	2¼	4¾	6¼	13	19½	31	40

Valves in stock for relieving pressures up to 900 lb.

Since every valve is factory set for the required relieving pressure, orders should include information concerning service, frequency of operation, and relieving pressure. For data on other standard Edward globe and angle stop, check, gate, blow-off, non-return, feedline, gage and plug valves and strainers. Write for Catalog 103.

Edward Valves, Inc.

Subsidiary of Rockwell Manufacturing Co.

EAST CHICAGO, INDIANA

(8) *Oxygen recorder*

An automatic continuous analyzer for indicating and recording the oxygen content of a gaseous mixture has been developed by Bailey Meter Company, Cleveland, Ohio. This instrument has been successfully applied to boiler furnaces, kilns, many types of metallurgical furnaces, glass tanks, chemical and petroleum processes.

The instrument provides a graphic analysis almost instantly, and is said to be responsive to changes of 0.05 per cent oxygen. Sustained accuracy is said to be within 0.25 per cent.

To operate, a continuous gas sample is mixed with a vaporized liquid fuel and burned on a catalyst-filament that reaches a temperature proportional to the oxygen content. The filament resistance is a function of temperature and a simple resistance bridge is connected to a null balance electronic recorder that may be calibrated in excess air, per cent oxygen, or other desired terms.

A high speed sampling system for handling dirty, high temperature gases is supplied with the instrument when required.

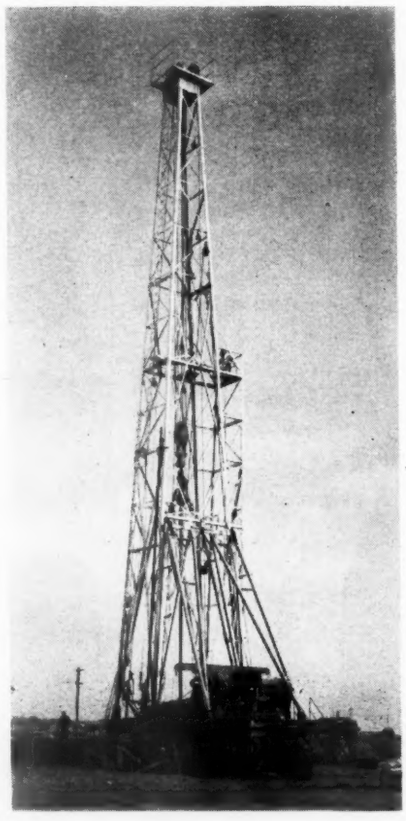
Oxygen recorders applied to all types of furnaces operating with oxidizing atmospheres permit closer regulation of fuel-air ratios, especially where multiple fuels are used, or where the firing rate changes rapidly. This results in not only greatly increased economy but also in decreased furnace maintenance. With process furnaces, it insures greater uniformity and higher quality of product, it is stated.

The high speed of the instrument makes it ideally suited for traverse studies, and other types of test work, as well as continuous day-to-day operation.

(9) *Emsco bulge mast*

Indicative of the intense exploration that is being devoted to all phases of the mobility problem, is the recent development of a bulge type portable mast by Emsco. This unit is shop fabricated in sections convenient for hauling and may

Emsco bulge type portable mast in upright position.



Solves Your Deep Well Mud Cleaning Problems

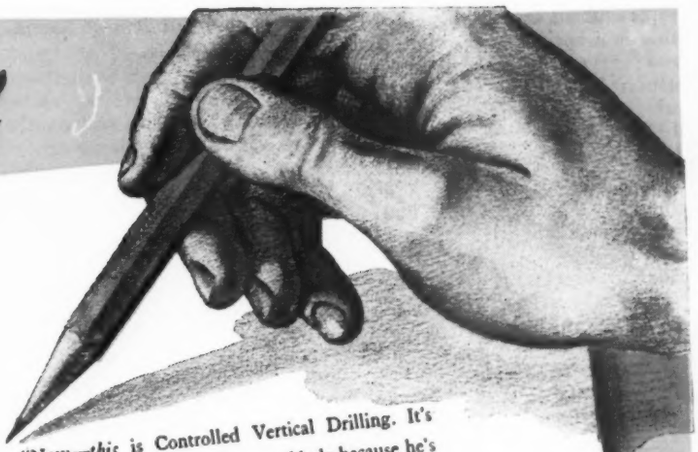
The new and improved Thompson Model "DW" Shale Separator and Sample Machine will efficiently handle the flow of mud from the largest mud pumps now in operation. Shale and abrasives are removed, which means less wear and tear on costly drilling equipment. Attached Sample Machine is standard equipment, unless otherwise specified . . . field-tested method of obtaining accurate foot by foot samples of cuttings. Adopt the Thompson as Standard Equipment. There are two other models, each tailor-made to fit your requirements from the smallest to the largest well. Place your order through your supply dealer or direct to us . . . WE CAN DELIVER NOW!

★ SELF-MOTIVATED
★ RECONDITIONS MUD
★ ACCURATE SAMPLES
★ UNLIMITED CAPACITY

THOMPSON TOOL CO.
IOWA PARK, TEXAS

KEEPS DRILLING MUD CLEAN — PROVIDES TRUE SAMPLES OF CUTTINGS

"Maybe this will help explain CONTROLLED VERTICAL DRILLING"*



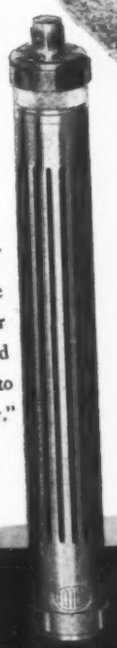
"So they said down at the office that I know something about drilling vertical wells, eh? Well, I ought to . . . I've drilled a lot of 'em.

"First off, let's get it straight what Controlled Vertical Drilling is *not*. It's *not* this. Even if a hole like this bottoms dead center under the rotary, it's *not* a "controlled vertical" well. It never has been, and never will be anything but trouble. Trouble drilling, with extra bits, maybe twist-offs, keyseating, washouts, fishing jobs. Trouble running casing and cementing. And trouble every year it is on production.

"Then there's this — Controlled Directional Drilling, where you're trying to hit a spot some distance from the derrick . . . out under water, say. Reason I mention it is, a lot of men get confused. They think Controlled Directional Drilling and Controlled Vertical Drilling are the same thing used two different ways. That's wrong. They're two entirely different methods. And the methods and equipment used in one won't work in the other—just remember that!

"Now—*this* is Controlled Vertical Drilling. It's where the driller makes plenty of hole because he's always using the correct weight and speed—*straight* hole because he never lets it get beyond the critical angle. Critical angle? That's the angle at which the forces which cause hole deflection really become established. It varies with the size of the hole, drill collar, and so on, but it's always small. Some men figure it something less than 2 degrees: me, I'd like to keep the angle of the hole less than 1 degree. Any deviation less than that is easy to correct, but you can buy yourself a lot of grief if hole deflection gets beyond that angle.

"How do you know what the hole's doing? A smart question, because that's the heart of Controlled Vertical Drilling. The driller's *got* to know what's happening every foot of the way. And the only way to know is to take frequent readings with an inclination recorder that's accurate down to small fractions of one degree. I use a Totco Recorder myself—been using it for years—because it *is* accurate to less than an eighth of a degree, because I can *always* depend on its readings, because it's simple to use, and can be dropped down the drill pipe, run on measuring or sand line, or with retractable coring equipment.



"That's the whole basis of Controlled Vertical Drilling . . . take frequent readings with a reliable recorder; never let hole deflections get beyond the critical angle; use the information the recorder supplies as a guide for correct weight and speed to cut each formation efficiently. That's the way to drill *better* wells, drill 'em faster, drill 'em cheaper."

*Based upon the actual statements of hundreds of drillers and drilling superintendents in all parts of the country, and in many foreign fields.

TOTCO

TECHNICAL OIL TOOL CORP., Ltd.

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Exclusive Distributors: California — REPUBLIC SUPPLY COMPANY OF CALIFORNIA • Domestic (outside California) — CONTINENTAL SUPPLY COMPANY • Canada — OIL WELL SUPPLY COMPANY • Export (except Canada) — LUCEY EXPORT CORP., New York

be assembled on the ground or on cribbing in a horizontal position. The crown and traveling block are completely strung for drilling before the mast is raised, and the latter is then raised with the drawworks—any standard unitized drawworks and rotary table may be used.

All 4 faces of the mast are laced, thus eliminating the need for interior bracing, giving full visibility and adding rigidity. The bulge feature permits all pipe to be racked inside the derrick. No guying is necessary and the mast is designed to withstand a 70-mile wind, with a full set-back of pipe standing in the bulge. It will accommodate 108 stands of 4½-in. O.D. pipe, and correspondingly more or less of the smaller and larger sizes.

The mast is made in 2 sizes, one with a 94-ft. derrick, having a capacity of 437,000 lb., and another with a 129-ft. derrick, having a capacity of 537,000 lb. The small derrick racks the number of stands of pipe already indicated in doubles, whereas the larger derrick will take the same number of stands in trebles. For compact and convenient moving, this unit is equipped with a skid base that may be broken down into 2 main sections, connected by short beams. The erection gin pole, which is left standing for lowering the derrick, is not an essential part of the mast, but is so connected as to add stability and strength to the total assembly.

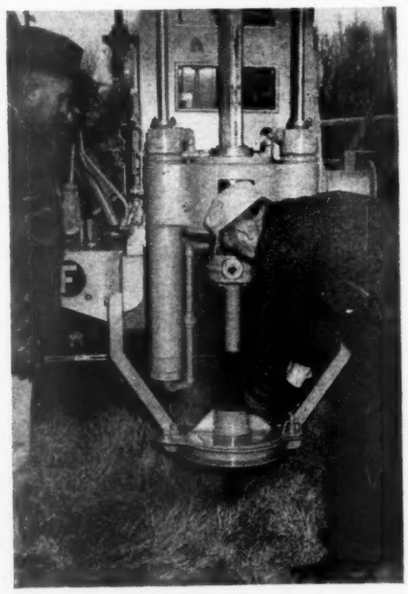
The crown block is concentrically mounted, equalizing the load on the mast legs, and a built-in deadline anchor is designed with a special cradle that makes the device suitable for anchoring all hoist lines. A cathead sheave is standard equipment, and alternate positions for mounting are provided. The entire arrangement has been planned with due consideration not only of the mechanics involved, but also of the economics of operation, and the safety of the operators. In order to prevent a dropped mast, a safety latch automatically drops into place under the front leg, just before the mast reaches the vertical, and remains in position until deliberately released. Adequate platform space is provided to permit servicing the crown block with safety, and to take care of all other operations normally performed from the platform. Ladders are also installed in positions and in a manner to take care of every likely contingency.

(10) *Swinging spider*

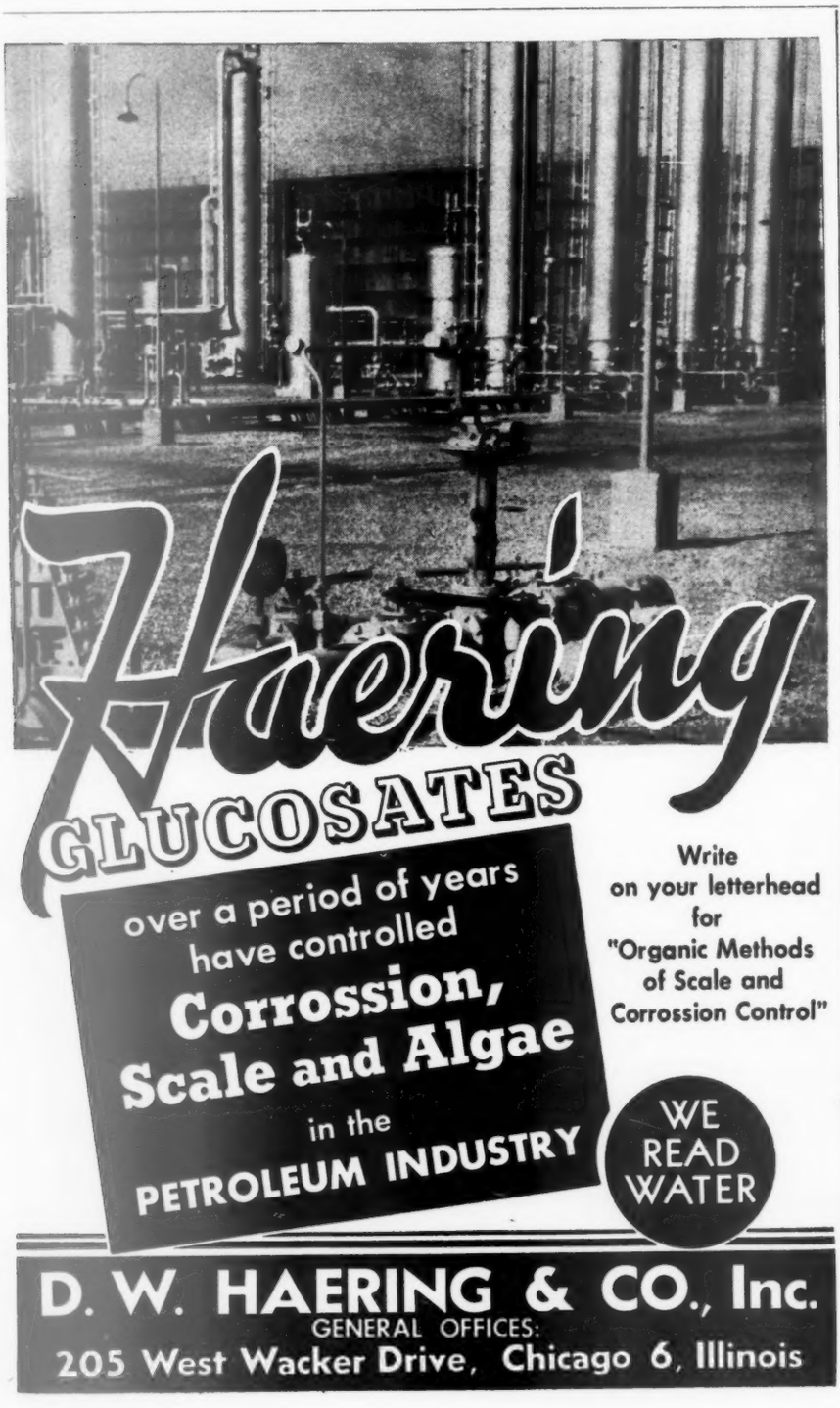
A new swinging spider arrangement on portable drills for holding the drill pipe while making it up or breaking it out, has been announced by the Geo. E. Failing Supply Company, of Enid, Oklahoma, and Houston, Texas. The new spider is designed to handle up to 400 ft. of N drill pipe and it saves considerable time in setting up, for it eliminates the need for leveling or aligning, required with the conventional footclamp or spider, according to the manufacturer.

The swinging spider frame is fastened permanently to the bed of the truck on a hinge. It locks down in place for drilling operations or locks up for road travel. The spider bowl also is hinged and swings horizontally away from the hole easily and quickly while drilling or setting large diameter surface pipe.

The new spiders are listed as optional equipment on Failing Drill Models 314, 314-C and 1500. Installation is simple.



Setting slips with Failing swinging spider.



Tough ones for TAYLOR FORGE *mean good ones for you*

In anybody's language this is SOME Welding Fitting . . . a cross nearly five feet long (forged from 2-5/16" thick seamless carbon moly tubing) 22" I.D. in the run with 20" I.D. and 14" I.D. outlets forged integrally to close tolerances. We made a number of fittings like this to replace another type that had begun to show signs of failure under severe service in an important oil refinery job. It was a difficult and exacting job—in this respect only typical of many others that are turned over to us almost daily!

As a user of Welding Fittings in standard sizes and types, what does it matter to you that Taylor Forge is almost continually doing things with hot metal that nobody else does? Only this:—

It is the specialized "know-how" accumulated through years of experience in handling the unusual jobs that enables us to make Taylor Forge Welding Fittings *exactly* as they should be made . . . to incorporate in them the soundest engineering principles . . . to give them features that bring extra value to users.

WeldELLS provide an outstanding example of this specialized skill and knowledge. Consider such features as the selective reinforcement that provides uniform strength, the tangents which keep the weld away from the most highly stressed zone, the accurately sized ends and extreme accuracy of all other dimensions. Consider, in fact, all of the features listed opposite and we believe you will agree that

WeldELLS alone combine these features:

- **Seamless**—greater strength and uniformity.
- **Tangents**—keep weld away from zone of highest stress—simplify lining up.
- **Precision quarter-marked ends**—simplify layout and help insure accuracy.
- **Selective reinforcement** — provides uniform strength.
- **Permanent and complete identification marking** — saves time and eliminates errors in shop and field.
- **Wall thickness never less than specification minimum**—assures full strength and long life.
- **Machine tool beveled ends** — provides best welding surface and accurate bevel and land.
- **The most complete line of Welding Fittings and Forged Steel Flanges in the World**—insures complete service and undivided responsibility.

WeldELLS have everything

TAYLOR FORGE & PIPE WORKS, General Offices & Works: Chicago, P.O. Box 485
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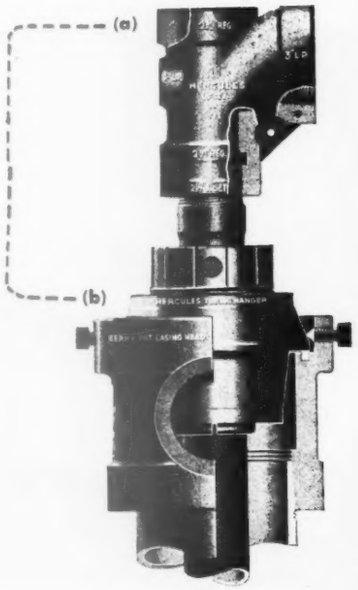

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WHAT A DIFFERENCE...

HERCULES PUMPING WELL HOOK-UP MAKES!

Note how the Hanger sits down in the casing head out of the way; the compactness of the entire hook-up . . . reducing the number of connections necessary in connecting a well the old way.

(a) Hercules Pumping and Flowing Tee is the original and only Tee with a combination Plain and EUE thread. (Supplied in any combination.) Heavier and stronger than an ordinary Tee.

(b) Hercules Forged Steel Tubing Hanger—with Forged Steel Slips on which tubing hangs—affords absolute tubing protection. Has the FAMOUS Hercules Packing above slips with threaded nut to distort packing, independent of tubing weight. (Fits any Berry Pattern Casing Head.)

Sold at all supply stores

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HERCULES TOOL COMPANY

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EXPORT OFFICE: 30 Rockefeller Plaza
NEW YORK, U.S.A.
CABLE ADDRESS: HERTOCO

(11) *Cementing collars*

Baker Multiplex cementing collars and equipment provide an efficient and economical means of performing a multi-stage cementing job without the use of an auxiliary cementing string or special running-in tools of any kind, it is said.

The Baker Multiplex cementing collar with steel sleeve is a collar of special design provided with a number of cementing ports (see Figs. 1 and 2). Acting as a back-pressure valve on the periphery of the collar is a resilient rubber valve sleeve reinforced with bias canvas and protected by a steel sleeve around its exterior. The collar contains a drillable

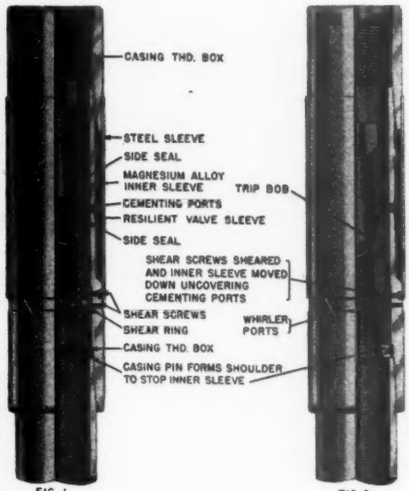


FIG. 1
UNTRIPPED POSITION

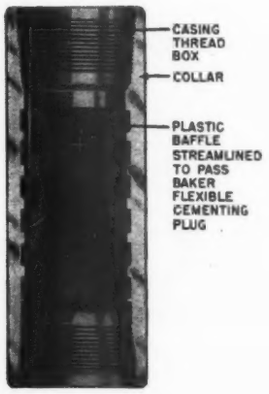
FIG. 2
TRIPPED POSITION

magnesium alloy inner sleeve that is held in place with shear screws to cover the cementing ports until tripped by means of the trip bob supplied with the collar. These trip bobs are made from a magnesium alloy and are lead-filled to provide weight. A resilient sleeve is provided as a covering for the lower end of the trip bob to insure sealing off in the seat in the magnesium sleeve.

The Baker flexible cementing plug, which is used in performing a multi-stage cementing job, has not been changed in any manner.

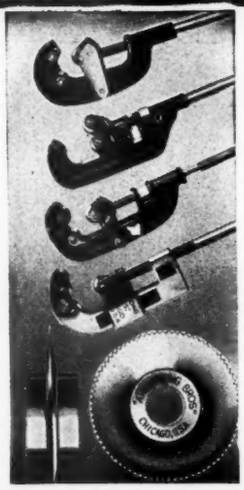
A new Baker Multiplex plastic baffle

FIG. 3



Look for the Arm-and-Hammer

ARMSTRONG BROS.



ARMSTRONG BROS. Pipe Cutters are made in all standard types. Each is a quality tool with hardened steel pins and rollers. "Saunders Type"—hardened end of thrust rod bears on inserted hard steel block (double life). In "Drop Forged" and "Combination" types, which take either 1 or 3 wheels, a replaceable hardened steel nut takes up thrust. In the "Barnes" type thrust rod threads through drop forged steel section.
ARMSTRONG BROS. Knife Blade Cutter Wheels (smooth or knurled) have thin penetrating edges that hold their keenness because they are machined from special vanadium tool steel, hardened and oil tempered. Fit all standard-make pipe cutters. . . . *Write for Catalog.*

ARMSTRONG BROS. TOOL CO.
"The Tool Holder People"
331 N. FRANCISCO AVE. • CHICAGO, U.S.A.
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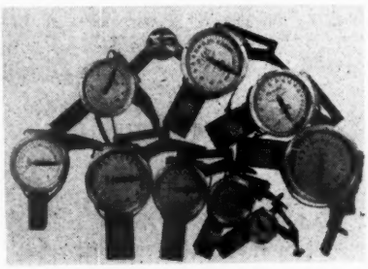
LINE SCALES



10 of the 20 Models we manufacture. 40,000 pounds to 500,000 pounds. A special scale for any job.

With a Line Scale you know the pull on the line, and the weight on the bit in pounds. Accurate, sensitive, rugged and economical.

Line Scales are dependable, even in areas of rapid temperature changes. Repeated tests prove the accuracy of Line Scale readings under all working conditions.

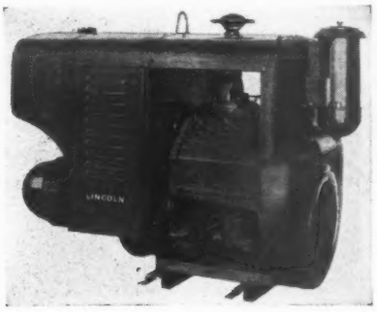
See your supply man, now.

LINE SCALE CO., INC.
Phone 2-1765, 907-11 SE. 29th Street, Box 4245
OKLAHOMA CITY, OKLAHOMA

collar has been added to this line. This unit (see Fig. 3) consists of a special steel collar and a plastic baffle streamlined to pass a Baker flexible cementing plug. It serves as a stop for the conventional cementing plug that would be used to follow up the slurry when cementing the uppermost stage of a multi-stage cementing job. It is positioned one or two joints above the uppermost multiplex cementing collar to insure that all mud-contaminated cement is left inside the casing.

(12) *Lincoln welder*

A new portable welder of the gasoline engine-driven type, especially designed to bring to the welding industry for the first time, a very inexpensive, complete,



New Lincoln "Shield Arc Jr." 200-amp. welder of the engine-driven portable type.

light weight portable welder for the price normally paid for the welding generator alone, is announced by The Lincoln Electric Company, Cleveland.

Of particular value for welding applications in areas where electric power is not readily available such as farms, oil and gas fields, construction work, etc., this 200-amp. welder known as the "Shield-Arc Jr.", is of exceptionally compact design measuring 24 by 48 by 30 in. and weighing much less than the usual equipment of this type and size.

With a current range of from 40 to 250 amp., the machine can be used for the welding of light or heavy gage metal, for the repair of cast-iron structures such as engine blocks, for the construction of various contrivances or the repair or fabrication of tools and machinery parts, and for hard facing of worn parts.

(13) *Electric light plant*

A new combination voltage electric light and power plant is now available by Fairbanks, Morse and Company, according to the recent announcement made by R. W. Lewis, the company's dealer division sales manager.

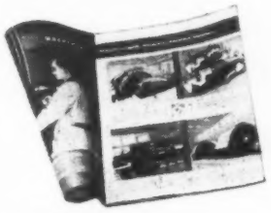
This new unit produces both alternating and direct current simultaneously. The entire output of the plant (3000 watts) may be used as 115-volt, 60-cycle alternating current with low charging rate to the 32-volt batteries, or any quantity of 32-volt, direct current up to 750 watts plus the remainder in a.c.

Another feature, it is pointed out, is that the 32-volt batteries can be charged at the same time the unit is supplying alternating current for the motors, etc.

Disastrous accidents and costly shutdowns can be reduced when they are caused by fatigue cracks, faulty welds and other *dangerous flaws* in equipment. Early detection is half the battle of protection . . . and the best assurance of safe, trouble-free operation.

Through MAGNAFLUX FIELD INSPECTION, the Magnaflux Corporation offers a complete, fast, non-destructive inspection service for all types of metallic and non-metallic materials. Magnaflux and Zyglo, two basic types of non-destructive testing means it can be applied to a full range of conditions — *at regular intervals.*

Significantly, Magnaflux Field Inspection Service can be scheduled to fit in conveniently with production processes. It will pay you to investigate the possibilities of this highly-effective, low-cost protection. *Write today for full details including new illustrated bulletin.*



Get the Facts . . . Write for this New Illustrated Bulletin . . .

When you write for information, ask specifically for this valuable bulletin . . . it features new and interesting facts about Magnaflux Field Inspection Service that offers dependable, low-cost protection against equipment failure. Quick service is assured by strategic location of Magnaflux Field Engineers at key points throughout the country.

MAGNAFLUX CORPORATION

* *Magnaflux — Zyglo — Registered U. S. Patent Office, trade names of the Magnaflux Corporation applied to its equipment and materials for magnetic particle and fluorescent penetrant inspection.*

MAGNAFLUX CORPORATION
Northwest Highway, Chicago 31, Illinois
New York • Detroit • Dallas • Los Angeles • Cleveland

(14) *Bucyrus-Erie spudder*

A new all-steel portable spudder—the 28-L for drilling and servicing to moderate depths—has been announced by Bucyrus-Erie Company, south Milwaukee, Wisconsin. The new machine expands to 4 models their current spudder line, which also includes the larger 36-L and the smaller 24-L.

Similar to the 36-L in design and construction, the 28-L is built to drill top-to-bottom oil and gas wells to 2500 ft., to handle drilling-in operations, cleaning-out, repairing, and other servicing work to much greater depths, the manufacturer states.

Outstanding features of the 28-L, according to Bucyrus-Erie, are its portability, which permits fast job-to-job moves; its easy rigging-up; its fast line speeds and powerful line pulls, and its accurate control and efficient drilling action.

The derrick is a cantilever-braced, latticed box structure of the telescoping type, raised and extended by a built-in power winch. It can be erected in less than a half-hour. With extra casing tackle, it has capacity for handling up to 45,000 lb. static load; an auxiliary derrick leg (extra equipment) permits loads as high as 75,000 lb.

Mountings available are dual pneumatic-tired semi-trailer with trailer hitch, and skid-type base for sliding to oil-field trucks. Reels include bull reel, sand reel, and casing reel. All have two speeds forward and one reverse, and are controlled through operating levers grouped at the machine's drilling end. The bull reel spools up to 4620 ft. of ¾-in. line; sand reel spools 4450 ft. of ½-in. Fully automatic spooling saves cable by preventing piling up and pinching on the reels.

(15) *Airco electrode*

A new all-position mild steel electrode, called Airco No. 312, has been announced by Air Reduction Sales Company, 60 East 42nd Street, New York City 17. It was designed primarily to prevent underbead cracking in the welding of hardenable steels.

Laboratory tests and field applications indicate this electrode is satisfactory for welding the following:

(1) Low alloy, high tensile steels, particularly in heavy sections where preheat must be used with conventional type electrodes to minimize cracking.

(2) Free machining steels that normally run quite high in sulphur.

(3) Cold-rolled steels where excessive porosity is normally encountered with conventional type mild steel electrodes.

For material to be vitreous-enameled after welding, this electrode makes possible production of highly satisfactory enameled surfaces without any preheat treatment prior to the enameling operation, it is asserted.

Airco No. 312 should also prove suitable on low alloy or mild steel applications where stress relieving would be desirable but cannot be accomplished, either due to lack of facilities or the magnitude of the application.

(16) *Larger swivel*

Already well known for its line of smaller swivels, The Brewster Company, Inc., Shreveport, Louisiana, has announced the availability of a new heavy duty oilbath model designated as the 6HD rated at 250 tons static load and a drilling depth of 10,000 ft.

Like all other swivels of this line the 6HD has all bearings and other moving parts submerged in an oil bath, the capacity of which is 18 gal. Heavy duty oil seals are used throughout to keep the oil in and foreign matter out. Three anti-friction bearings are used, two straight roller and one tapered roller, to handle all loads with a minimum friction loss.

The main body of the swivel is cast steel and has a smooth design to prevent hanging up on obstructions. Alloy steels for each specific part are carefully selected and heat treated for maximum strength and long life.

Fluid passage is 3 in. Wash pipe is specially hardened and ground to give a smooth long wearing surface.

According to the Brewster Company, the Model 6HD Oilbath Swivel is available for immediate delivery from the Shreveport plant.

Because they have built into them the vital, extra capacity for smooth, dependable, trouble-free operation under the severest stresses and strains to be encountered in the world's most powerful machinery, AMERICAN SUPER HEAVY-DUTY ROLLER BEARINGS have been first choice for over 25 years with most manufacturers of heavy industrial and oil country equipment. Brutally strong, simply constructed, precise—AMERICANS give continuous, 24-hour-a-day service for maximum periods with minimum maintenance, often outlasting the equipment itself. Once adopted, no manufacturer has ever had to switch from AMERICANS.

Write for specifications or send us your requirements for analysis and recommendations. Our engineering experience is at your service without obligation.

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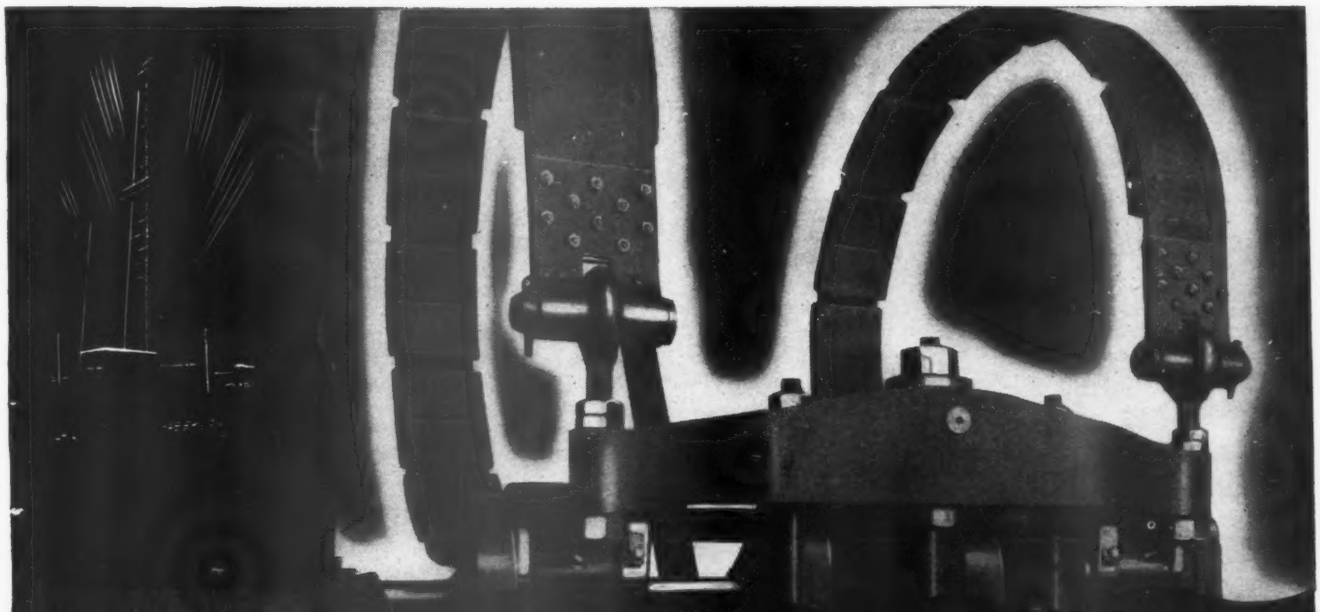
AMERICAN
Heavy-Duty ROLLER BEARINGS



THERMOID-GRIZZLY MAKES EVERY TYPE OF OIL FIELD BRAKE LINING

No single friction material can meet the varied requirements of the many types and kinds of oil field equipment. Brake drums are made of different materials, applications vary—making necessary different coefficient of friction liners. Thermoid engineers, with years of experience behind them, have developed a *complete* line of braking materials suitable for all types of drawworks and pulling machines.

Thermoid-Grizzly Friction Materials are available in Full Molded Blocks, Woven Blocks—metallic and non-metallic —countersunk and drilled. Woven material can also be supplied in roll lots.

For specifications, write to our nearest warehouse for catalog 3001.

Thermoid

Thermoid OIL FIELD PRODUCTS

TRADE LITERATURE

Publications listed are sent free upon request.

(17) *Liquid level gages*

Jerguson Gage and Valve Company, Somerville, Massachusetts, has issued a bulletin describing reflex, transparent, and special type gages manufactured by the company, as well as its line of gage valves. In addition to descriptive material, pictures of the various gages are shown, together with engineering data and prices.

(18) *Ideco equipment*

International Derrick and Equipment Company, Columbus, Ohio, has released Bulletin R-45 on the Ideco streamlined rotaries for oilfield drilling, and Bulletin P-45 on Ideco geared pumpers. Both bulletins present in an effective manner the features of these two items of equipment.

(19) *Drilling engine*

The Superior PTD diesel drilling engine, designed for the heavy duty requirements of oil field service, is the subject of Bulletin 318 of The National Supply Company. Complete specifications are given in the bulletin, photographs show the numerous features of the equipment, and a group of curves give extensive operating data.

(20) *"Oilwell" equipment*

Recently issued bulletins give factual data on several items of oil field equipment manufactured by the Oil Well Supply Company, Dallas, Texas.

Bulletin U14-1145 describes the TC-5HB and TC-8B twin crank pumping units.

The "Oilwell" Wilson-Snyder No. 612-P power slush pump (6 in. by 12 in.) is the subject of Bulletin P19-1245.

The No. 1525 welded boiler is discussed in Bulletin B10-1045.

(21) *Fiberglas mat*

Owens-Corning Fiberglas Corporation, Toledo, Ohio, has issued a bulletin on its Fiberglas mat. The publication describes the composition of the mat, its properties, and its numerous uses in industry.

(22) *Pump bulletin*

Sixty types and styles of vertical and horizontal pumps manufactured by Peerless Pump Division of Food Machinery Corporation are presented in a new Bulletin (B-136) issued by the concern. Types include deep and shallow well pumps, Hi-Lift pumps, and domestic water systems.

(23) *Feed water heater*

The Swartout Company, 18511 Euclid Avenue, Cleveland, Ohio, announces publication of Bulletin S-18-E describing and illustrating its deaerating and standard open feed water heaters.

(24) *Regenerating spent acid*

A bulletin describing an efficient method of regenerating spent sulphuric acid for the alkylation process in the production of high octane gasoline has been prepared by Chemical Construction Corporation. The bulletin explains this method by which fresh 98 per cent acid is obtained from the spent alkylation acid, and includes a large diagrammatic arrangement of the process, with an accompanying explanation of each step and apparatus used in the process. Among the features mentioned are the economical method of forming make-up acid, the elimination of fuel for maintaining the furnace temperature, and the convertability of the plant to processing other refinery acid sludges.

(25) *Steam detergent cleaning*

Of increasing interest to petroleum industry executives, superintendents, and foremen responsible for plant machinery and equipment maintenance cleaning are the savings in time, money, and effort being effected by steam detergent cleaning methods. A booklet on this subject has been published by Oakite Products, Inc.

Described in this booklet are many applications of steam detergent cleaning for: (1) Cleaning machinery equipment and parts for subsequent repair and overhaul, (2) preparing equipment surfaces for repainting or refinishing, (3) cleaning equipment too large for tank immersion, or where suitable tanks are not available, and (4) paint stripping. Emphasis is placed on steam detergent cleaning as a simple, fast method for safely removing grease, oil, dirt, sand and other deposits from all types of equipment through the combination of mechanical force, controlled heat, and effective detergent action of recommended materials.

(26) *General service pumps*

Ingersoll-Rand Company announces the publication of a new 20 page, two-color catalog covering the design, construction, and engineering details of its Cameron single-stage general service pumps.

These pumps, embracing one type out of a number of centrifugal pump models offered by the company, are suitable for a wide variety of services wherever liquids have to be handled. Their applications include condenser circulation, air conditioning equipment, transfer service in sugar refineries, chemical plants, oil-tank farms, beverage plants, food-packing plants and many other industrial hydraulic requirements.

These single-stage units are designed for capacities to 25,000 g.p.m., against heads up to 300 ft. They are available in several combinations of metals for a wide variety of liquids.

(27) *Aluminized steel booklet*

"Armco Aluminized Steel" is the title of an attractive 24-page booklet that describes one of Armco's newest special-purpose sheet steels for resistance to heat and corrosion. It is published by The American Rolling Mill Company, Middletown, Ohio.

Aluminum-coated on both sides, Aluminized Steel resists destructive heat scaling up to 1500°F. It maintains a bright shiny appearance after prolonged heating up to 900°F., has good atmospheric corrosion resistance, and good radiant heat reflectivity. In addition, this new sheet possesses the strength of steel at moderately elevated temperatures and has a lower coefficient of expansion than some of the widely used non-ferrous metals.

(28) *Insulation materials*

The Philip Carey Manufacturing Company has released a revised edition of its heat insulation materials catalog, "Heat Insulation for Industry."

The catalog has been prepared to facilitate the specification and purchase of heat insulation for industrial and commercial use. In addition to complete information on the more than 40 Carey heat insulation products, the catalog offers a wealth of helpful and practical data. For instance, the new catalog offers heat loss tables, selection charts and data for determining insulation thickness, data on the comparative efficiencies of the various types of Carey insulation, mechanical, thermal and performance characteristics—and a great deal of other helpful information.

(29) *Dozer-Shovel bulletin*

A new 24-page bulletin describing the Dozer-Shovel for International TracTracTors has just been issued by Bucyrus-Erie Company, South Milwaukee, Wisconsin. Colorfully illustrated with numerous large photographs and pen drawings, the new bulletin graphically depicts actual operating conditions on a wide variety of digging, earthmoving, and material-handling jobs.

THE *Petroleum* Engineer's CONTINUOUS TABLES

A DAILY REFERENCE FOR OPERATING MEN

INSTALLMENT No. 105

A VALUABLE and regular feature of *The Petroleum Engineer,* the Continuous Tables, now in their eighth year of publication, were designed to save time and effort for the technician and the practical field or plant worker. The tables have proved one of the most popular and helpful departments of *The Petroleum Engineer.* Data are presented in the simplest form available with many types of information included that are best presented by curves or nomographs when three or more variables must be considered simultaneously.

The Continuous Tables have developed as a result of suggestions for new tables, direct contributions, and improvements to existing tables by members of the petroleum and related industries, including manufacturing concerns, who are continually searching for practical information reduced by computation to tabular form readily applicable to the problems daily confronting them that might otherwise necessitate a more or less tedious calculation. These contributions and suggestions from the industry have resulted in a valuable exchange of information and data contributing to the progress of the industry as a whole.

This index will be revised monthly. The index for installments 1-12, inclusive, will be found in the May, 1938, issue; 13-24, inclusive, in the June, 1939, issue; 25-36, inclusive, in the June, 1940, issue; 37-48, inclusive, in the June, 1941, issue; 48-60, inclusive, in the June, 1942, issue; 61-72, inclusive, in the June, 1943, issue; 73-79, inclusive, in the January, 1944, issue; 80-82, inclusive, in the April, 1944, issue; 83-85, inclusive, in the July, 1944, issue; 86-88, inclusive, in the October, 1944, issue; 89-91, inclusive, in the January, 1945, issue; 92-94, inclusive, in the April, 1945, issue; 95-97, inclusive, in the July, 1945, issue; 98-100, inclusive, in the October, 1945, issue, and 101-103, inclusive, in the January, 1946, issue.

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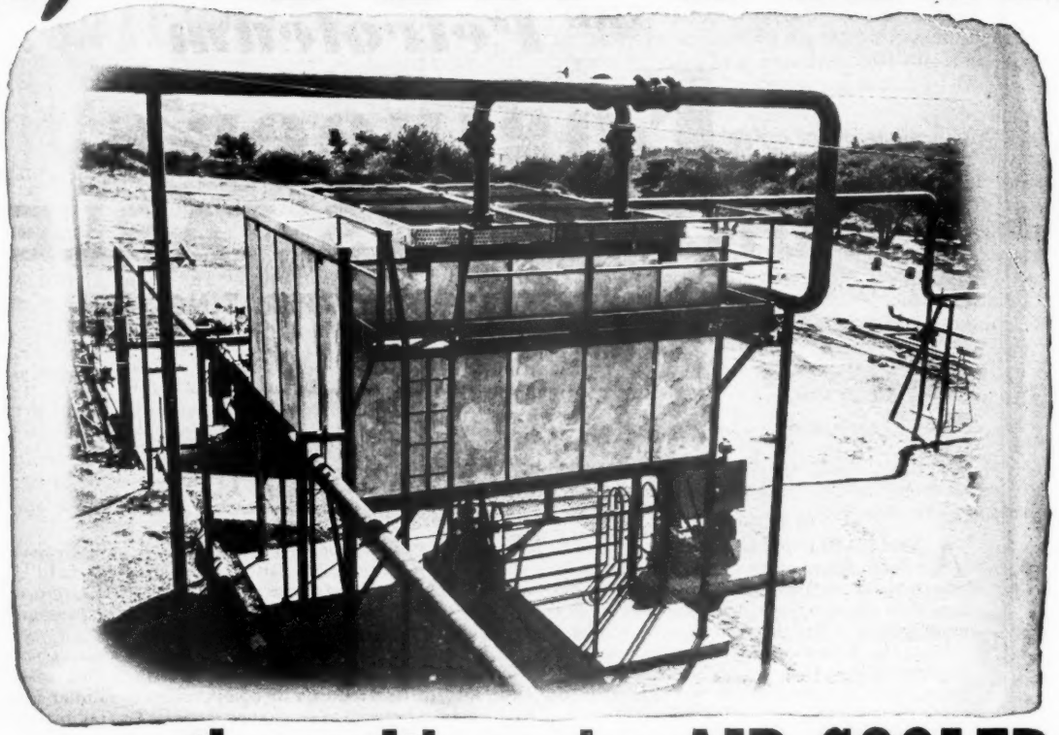
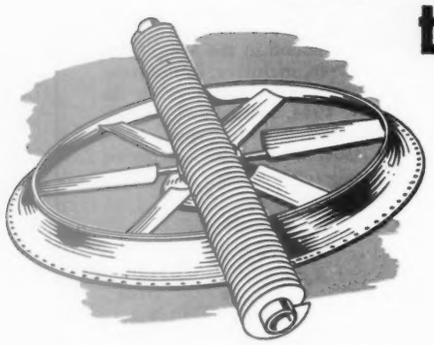
Investigate FIN-FAN su-



the multi-service AIR-COOLED sev- heat exchanger



This symbol denotes the principle of the FIN-FAN Air Cooled Heat Exchanger which combines the long Griscom-Russell experience in the field of heat transfer equipment and the extensive Fluor experience in air-moving systems, mechanical equipment and structures.

The important advantages of the FIN-FAN Exchanger warrants its investigation for practically every condensing and cooling service. Note these features:

PROVEN WIDE ADAPTABILITY highly successful operation under wide variety of duties—suitable for liquids, gases, and vapors at pressures up to 5,000 psi and temperatures up to 1500°F.

ECONOMICAL OPERATION independent of wind velocity or direction . . . forced draft air circulation with highly efficient fans having power saving variable pitch blades, and uniform air distribution over K-Fin cooling sections.

EASE OF INSTALLATION, OPERATION AND MAINTENANCE a complete, "package type" unit that can be installed on the ground or on top of buildings . . . no water supply equipment or piping . . . all mechanical equipment sturdy and readily accessible, with flexible operating control.

Write for complete information.

THE GRISCOM-RUSSELL CO.
285 Madison Ave., New York 17, N. Y.

Some FIN-FAN Applications
- Exhaust steam condensing
- Engine jacket water cooling
- Gas cooling
- Still overhead and reflux condensing and cooling
- Oil cooling
- Compressed air cooling
- Solution cooling
- Refrigeration system condensing

or a combination of one or more services with the same unit

GRISCOM-RUSSELL
Pioneers in Heat Transfer Apparatus

RECIPROCALS, CIRCUMFERENCES, AND AREAS OF CIRCLES

Diam. n	Reciprocal $1000/n$	Circumference of circle πn	Area of circle $\frac{1}{4}\pi n^2$	Diam. n	Reciprocal $1000/n$	Circumference of circle πn	Area of circle $\frac{1}{4}\pi n^2$
100	10.000 000	314.159 3	7 853.982	150	6.666 667	471.238 9	17 671.46
101	9.900 990	317.300 9	8 011.847	151	6.622 517	474.380 5	17 907 86
102	9.803 922	320.442 5	8 171.282	152	6.578 947	477.522 1	18 145 84
103	9.708 738	323.584 0	8 332.289	153	6.535 948	480.663 7	18 385.39
104	9.615 385	326.725 6	8 494.867	154	6.493 506	483.805 3	18 626.50
105	9.523 810	329.867 2	8 659.015	155	6.451 613	486.946 9	18 869.19
106	9.433 962	333.008 8	8 824.734	156	6.410 256	490.088 5	19 113.45
107	9.345 794	336.150 4	8 992.024	157	6.369 427	493.230 0	19 359.28
108	9.259 259	339.292 0	9 160.884	158	6.329 114	496.371 6	19 606.68
109	9.174 312	342.433 6	9 331.316	159	6.289 308	499.513 2	19 855.65
110	9.090 909	345.575 2	9 503.318	160	6.250 000	502.654 8	20 106.19
111	9.009 009	348.716 8	9 676.891	161	6.211 180	505.796 4	20 358.31
112	8.928 571	351.858 4	9 852.035	162	6.172 840	508.938 0	20 611.99
113	8.849 558	355.000 0	10 028.75	163	6.134 969	512.079 6	20 867.24
114	8.771 930	358.141 6	10 207.03	164	6.097 561	515.221 2	21 124.07
115	8.695 652	361.283.2	10 386.89	165	6.060 606	518.362 8	21 382.46
116	8.620 690	364.424 7	10 568.32	166	6.024 096	521.504 4	21 642.43
117	8.547 009	367 566 3	10 751.32	167	5.988 024	524.646 0	21 903.97
118	8.474 576	370.707 9	10 935.88	168	5.952 381	527.787 6	22 167.08
119	8.403 361	373.849 5	11 122.02	169	5.917 160	530.929 2	22 431.76
120	8.333 333	376.991 1	11 309.73	170	5.882 353	534.070 8	22 698.01
121	8 264 463	380.132 7	11 499.01	171	5.847 953	537.212 3	22 965.83
122	8.196 721	383.274 3	11 689 87	172	5.813 953	540.353 9	23 235.22
123	8.130 081	386.415 9	11 882.29	173	5.780 347	543.495 5	23 506.18
124	8.064 516	389.557 5	12 076.28	174	5.747 126	546.637 1	23 778.71
125	8.000 000	392.699 1	12 271.85	175	5.714 286	549.778 7	24 052.82
126	7.936 508	395.840 7	12 468.98	176	5.681 818	552.920 3	24 328.49
127	7.874 016	398.982 3	12 667 69	177	5.649 718	556.061 9	24 605.74
128	7.812 500	402.123 9	12 867.96	178	5.617 978	559.203 5	24 884.56
129	7.751 938	405.265 5	13 069.81	179	5.586 592	562.345 1	25 164.94
130	7.692 308	408.407 0	13 273.23	180	5.555 556	565.486 7	25 446.90
131	7.633 588	411.548 6	13 478.22	181	5.524 862	568.628 3	25 730.43
132	7.575 7?8	414.690 2	13 684.78	182	5.494 505	571.769 9	26 015.53
133	7.518 797	417.831 8	13 892 91	183	5.464 481	574.911 5	26 302.20
134	7.462 687	420.973 4	14 102.61	184	5.434 783	578.053 0	26 590 44
135	7.407 407	424.115 0	14 313.88	185	5.405 405	581.194 6	26 880.25
136	7.352 941	427 256 6	14 526.72	186	5 376 344	584.336 2	27 171.63
137	7.299 270	430.398 2	14 741.14	187	5.347 594	587.477 8	27 464.59
138	7 246 377	433.539 8	14 957.12	188	5 319 149	590.619 4	27 759.11
139	7.194 245	436.681 4	15 174.68	189	5.291 005	593.761 0	28 055.21
140	7.142 857	439.823 0	15 393.80	190	5.263 158	596.902 6	28 352.87
141	7.092 199	442 964 6	15 614.50	191	5.235 602	600.044 2	28 652.11
142	7.042 254	446 106 2	15 836 77	192	5.208 333	603.185 8	28 952.92
143	6.993 007	449 247 7	16 060.61	193	5.181 347	606.327 4	29 255.30
144	6.944 444	452.389 3	16 286.02	194	5.154 639	609.469 0	29 559.25
145	6.896 552	455.530 9	16 513.00	195	5.128 205	612.610 6	29 864.77
146	6.849 315	458.672 5	16 741.55	196	5.102 041	615.752 2	30 171.86
147	6.802 721	461.814 1	16 971.67	197	5.076 142	618.893 8	30 480.52
148	6.756 757	464.955 7	17 203.36	198	5.050 505	622.035 3	30 790.75
149	6.711 409	468.097 3	17 436.62	199	5.025 126	625.176 9	31 102.55

Note: n may be in any unit of measure, such as in., ft., yards, miles, meters, or fractions thereof.

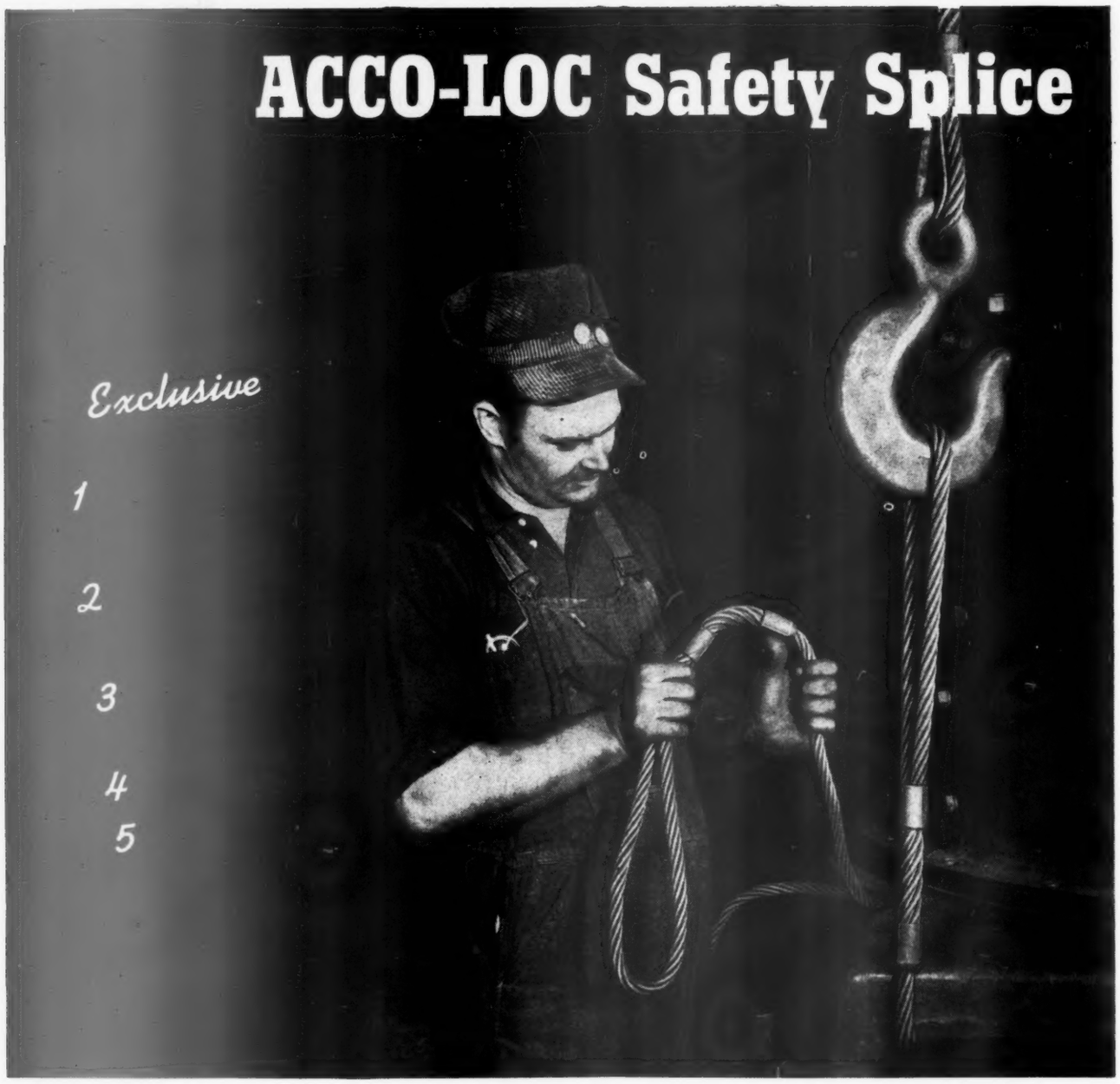
Example: The diameter of a circle = 1500 ft.

Then, the circumference = $1500 \times \pi = 4712.389$ ft. (The figure shown opposite 150 in the circumference column with the decimal moved one place to the right); and the area = 1,767,146 sq. ft. *Notice* that the decimal point is moved *the same number of places* to the right in pointing off for the circumference, and twice the *number of places* to the right for the area.

The *reciprocal* of a number is simply the quotient of unity (1000 is taken as unity in this table) divided by the number. It is useful in determining decimal equivalents of fractions.

Example: Opposite 180 (above), the reciprocal $\left(\frac{1000}{180}\right) = 5.555556$. Then, the decimal equivalent of the fraction 1/180 in. = 0.005555556 in. And, the decimal equivalent of the fraction 1/18 in. = 0.05555556 in. *Notice* that the decimal point is moved *the same number* of places in the denominators of the two fractions as in the answers, but in opposite directions.

ACCO-LOC Safety Splice



Here is a safer, more reliable wire rope ending. It has no awkward, bulky hand-tuck splicing. Instead, a neat, compact, flexible terminal that *always* develops 100% of the rope strength. May be used with any standard fitting. ACCO-LOC Safety Splice assemblies now available in stock sizes. Send today for literature.

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AMERICAN CHAIN & CABLE

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In Business for Your Safety

RECIPROCALS, CIRCUMFERENCES, AND AREAS OF CIRCLES

Diam. n	Reciprocal $1000/n$	Circumference of circle πn	Area of circle $\frac{1}{4}\pi n^2$	Diam. n	Reciprocal $1000/n$	Circumference of circle πn	Area of circle $\frac{1}{4}\pi n^2$
200	5.000 000	628.318 5	31 415.93	250	4.000 000	785.398 2	49 087.39
201	4.975 124	631.460 1	31 730.87	251	3.984 064	788.539 8	49.480.87
202	4.950 495	634.601 7	32 047.39	252	3.968 254	791.681 3	49 875.92
203	4.926 108	637.743 3	32 365.47	253	3.952 569	794.822 9	50 272.55
204	4.901 961	640.884 9	32 685.13	254	3.937 008	797.964 5	50 670.75
205	4.878 049	644.026 5	33 006.36	255	3.921 569	801.106 1	51 070.52
206	4.854 369	647.168 1	33 329.16	256	3.906 250	804.247 7	51 471.85
207	4.830 918	650.309 7	33 653.53	257	3.891 051	807.389 3	51 874.76
208	4.807 692	653.451 3	33 979.47	258	3.875 969	810.530 9	52 279.24
209	4.784 689	656.592 9	34 306.98	259	3.861 004	813.672 5	52 685.29
210	4.761 905	659.734 5	34 636.06	260	3.846 154	816.814 1	53 092.92
211	4.739 336	662.876 0	34 966.71	261	3.831 418	819.955 7	53 502.11
212	4.716 981	666.017 6	35 298.94	262	3.816 794	823.097 3	53 912.87
213	4.694 836	669.159 2	35 632.73	263	3.802 281	826.238 9	54 325.21
214	4.672 897	672.300 8	35 968.09	264	3.787 879	829.380 5	54 739.11
215	4.651 163	675.442 4	36 305.03	265	3.773 585	832.522 1	55 154.59
216	4.629 630	678.584 0	36 643.54	266	3.759 398	835.663 6	55 571.63
217	4.608 295	681.725 6	36.983.61	267	3.745 318	838.805 2	55 990.25
218	4.587 156	684.867 2	37 325.26	268	3.731 343	841.946 8	56 410.44
219	4.566 210	688.008 8	37 668.48	269	3.717 472	845.088 4	56 832.20
220	4.545 455	691.150 4	38 013.27	270	3.703 704	848.230 0	57 255.53
221	4.524 887	694.292 0	38 359.63	271	3.690 037	851.371 6	57 680.43
222	4.504 505	697.433 6	38 707.56	272	3.676 471	854.513 2	58 106.90
223	4.484 305	700.575 2	39 057.07	273	3.663 004	857.654 8	58.534.94
224	4.464 286	703.716 8	39 408.14	274	3.649 635	860.796 4	58 964.55
225	4.444 444	706.858 3	39 760.78	275	3.636 364	863.938 0	59 395.74
226	4.424 779	709.999 9	40 115.00	276	3.623 188	867.079 6	59 828.49
227	4.405 286	713.141 5	40 470.78	277	3.610 108	870.221 2	60 262.82
228	4.385 965	716.283 1	40 828.14	278	3.597 122	873.362 8	60 698.71
229	4.366 812	719.424 7	41 187.07	279	3.584 229	876.504 4	61 136.18
230	4.347 826	722.566 3	41 547.56	280	3.571 429	879.645 9	61 575.22
231	4.329 004	725.707 9	41 909.63	281	3.558 719	882.787 5	62 015.82
232	4.310 345	728.849 5	42 273.27	282	3.546 099	885.929 1	62 458.00
233	4.291 845	731.991 1	42 638.48	283	3.533 569	889.070 7	62 901.75
234	4.273 504	735.132 7	43 005.26	284	3.521 127	892.212 3	63 347.07
235	4.255 319	738.274 3	43 373.61	285	3.508 772	895.353 9	63 793.97
236	4.237 288	741.415 9	43 743.54	286	3.496 503	898.495 5	64 242.43
237	4.219 409	744.557 5	44 115.03	287	3.484 321	901.637 1	64 692.46
238	4.201 681	747.699 1	44 488.09	288	3.472 222	904.778 7	65 144.07
239	4.184 100	750.840 6	44 862.73	289	3.460 208	907.920 3	65 597.24
240	4.166 667	753.982 2	45 238.93	290	3.448 276	911.061 9	66 051.99
241	4.149 378	757.123 8	45 616.71	291	3.436 426	914.203 5	66 508.30
242	4.132 231	760.265 4	45 996.06	292	3.424 658	917.345 1	66 966.19
243	4.115 226	763.407 0	46 376.98	293	3.412 969	920.486 6	67 425.65
244	4.098 361	766.548 6	46 759.47	294	3.401 361	923.628 2	67 886.68
245	4.081 633	769.690 2	47 143.52	295	3.389 831	926.769 8	68 349.28
246	4.065 041	772.831 8	47 529.16	296	3.378 378	929.911 4	68 813.45
247	4.048 583	775.973 4	47 916.36	297	3.367 003	933.053 0	69.279.19
248	4.032 258	779.115 0	48 305.13	298	3.355 705	936.194 6	69 746.50
249	4.016 064	782.256 6	48.695.47	299	3.344 482	939.336 2	70 215.38

Note: n may be in any unit of measure, such as in., ft., yards, miles, meters, or fractions thereof.

Example: The diameter of a circle = 2.5 in.

Then, the circumference = $2.5 \times \pi = 7.853982$ in. (The figure shown opposite 250 pointed off for the fraction); and the area = 4.908739 sq. in. *Notice* that the decimal point is moved *the same number of places* to the left in pointing off for the circumference, and twice the *number of places* to the left for the area.

The *reciprocal* of a number is simply the quotient of unity (1000 is taken as unity in this table) divided by the number. It is useful in determining decimal equivalents of fractions.

Example: Opposite 240 (above), the reciprocal $\left(\frac{1000}{240}\right) = 4.166667$. Then, the decimal equivalent of the fraction 1/240 in. = 0.004166667 in. And the decimal equivalent of the fraction 1/24 in. = 0.04166667 in. *Notice* that the decimal point is moved *the same number* of places in the denominators of the fractions as in the answers, but in opposite directions.

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FAST
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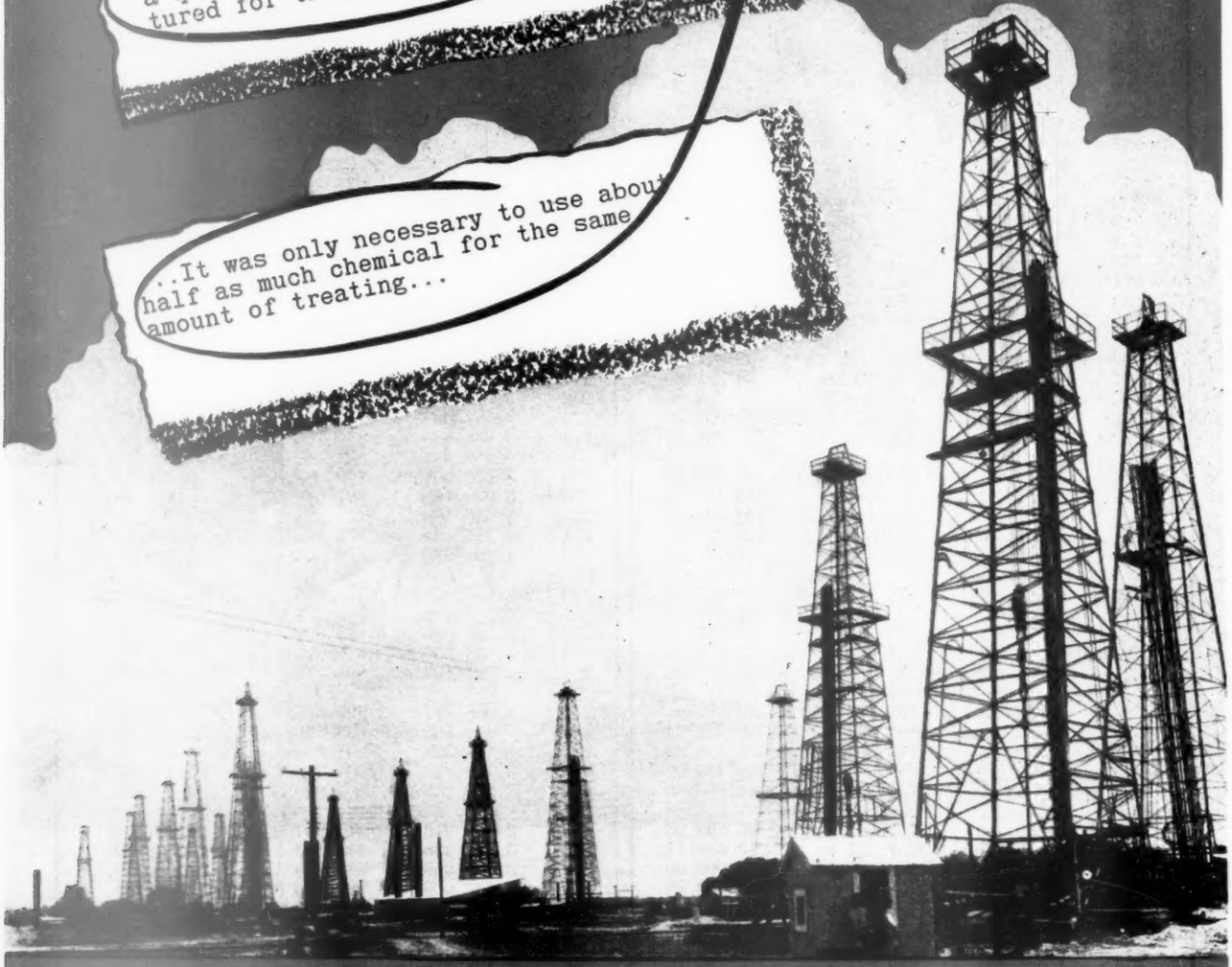
...Visco not only treats it out more readily but does not take as large a quantity as other chemicals manufactured for this purpose...

..It was only necessary to use about half as much chemical for the same amount of treating...



VISCO

The Modern Emulsion Breaker

VISCO PRODUCTS COMPANY, INC., Houston, Texas

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RECIPROCALS, CIRCUMFERENCES, AND AREAS OF CIRCLES

Diam. n	Reciprocal $1000/n$	Circumference of circle πn	Area of circle $\frac{1}{4}\pi n^2$	Diam. n	Reciprocal $1000/n$	Circumference of circle πn	Area of circle $\frac{1}{4}\pi n^2$
300	3.333 333	942.477 8	70 685.83	350	2.857 143	1 099.557	96 211.28
301	3.322 259	945.619 4	71 157.86	351	2.849 003	1 102.699	96 761.84
302	3.311 258	948.761 0	71 631.45	352	2.840 909	1 105.841	97 313.97
303	3.300 330	951.902 6	72 106.62	353	2.832 861	1 108.982	97 867.68
304	3.289 474	955.044 2	72 583.36	354	2.824 859	1 112.124	98 422.96
305	3.278 689	958.185 8	73 061.66	355	2.816 901	1 115.265	98 979.80
306	3.267 974	961.327 4	73 541.54	356	2.808 989	1 118.407	99 538.22
307	3.257 329	964.468 9	74 022.99	357	2 801 120	1 121.549	100 098.2
308	3.246 753	967.610 5	74 506 01	358	2 793 296	1 124 690	100 659.8
309	3.236 246	970.752 1	74 990.60	359	2.785 515	1 127.832	101 222.9
310	3.225 806	973.893 7	75 476.76	360	2.777 778	1 130.973	101 787.6
311	3.215 434	977.035 3	75 964.50	361	2.770 083	1 134.115	102 353.9
312	3.205 128	980.176 9	76 453 80	362	2 762 431	1 137.257	102 921.7
313	3.194 888	983.318 5	76 944.67	363	2.754 821	1 140.398	103 491.1
314	3.184 713	986.460 1	77 437.12	364	2.747 253	1 143.540	104 062.1
315	3.174 603	989.601 7	77 931 13	365	2.739 726	1 146.681	104 634.7
316	3.164 557	992.743 3	78 426.72	366	2.732 240	1 149.823	105 208.8
317	3.154 574	995.884 9	78 923.88	367	2.724 796	1 152.965	105 784.5
318	3.144 654	999.026 5	79 422.60	368	2.717 391	1 156.106	106 361.8
319	3.134 796	1 002.168	79 922.90	369	2.710 027	1 159.248	106 940.6
320	3.125 000	1 005.310	80 424.77	370	2.702 703	1 162.389	107 521.0
321	3.115 265	1 008.451	80 928 21	371	2.695 418	1 165.531	108 103.0
322	3.105 590	1 011.593	81 433 22	372	2 688 172	1 168.672	108 686.5
323	3.095 975	1 014.734	81 939 80	373	2.680 965	1 171.814	109 271.7
324	3.086 420	1 017.876	82 447.96	374	2.673 797	1 174.956	109 858.4
325	3.076 923	1 021.018	82 957 68	375	2 666 667	1 178.097	110 446.6
326	3.067 485	1 024.159	83 468.97	376	2 659 574	1 181.239	111 036.5
327	3 058 104	1 027 301	83 981.84	377	2 652 520	1 184.380	111 627.9
328	3.048 780	1 030.442	84 496 28	378	2 645 503	1 187.522	112 220.8
329	3.039 514	1 033.584	85 012.28	379	2.638 522	1 190.664	112 815.4
330	3.030 303	1 036.726	85 529.86	380	2.631 579	1 193.805	113 411.5
331	3.021 148	1 039.867	86 049.01	381	2.624 672	1 196.947	114 009.2
332	3.012 048	1 043 009	86 569.73	382	2.617 801	1 200.088	114 608.4
333	3.003 003	1 046.150	87 092 02	383	2.610 966	1 203.230	115 209.3
334	2.994 012	1 049.292	87 615.88	384	2.604 167	1 206.372	115 811.7
335	2.985 075	1 052.434	88 141.31	385	2.597 403	1 209.513	116 415.6
336	2.976 190	1 055.575	88 668 31	386	2 590 674	1 212 655	117 021.2
337	2.967 359	1 058 717	89 196 88	387	2.583 979	1 215.796	117 628.3
338	2.958 580	1 061.858	89 727 03	388	2 577 320	1 218.938	118 237.0
339	2.949 853	1 065.000	90 258.74	389	2.570 694	1 222.080	118 847.2
340	2 941 176	1 068.142	90 792 03	390	2.564 103	1 225 221	119 459.1
341	2 932 551	1 071.283	91 326 88	391	2 557 545	1 228.363	120 072.5
342	2.923 977	1 074.425	91 863 31	392	2.551 020	1 231.504	120 687.4
343	2.915 452	1 077.566	92 401.31	393	2.544 529	1 234.646	121 304.0
344	2.906 977	1 080.708	92 940.88	394	2.538 071	1 237.788	121 922.1
345	2.898 551	1 083.849	93 482 02	395	2.531 646	1 240 929	122 541.7
346	2.890 173	1 086 991	94 024.73	396	2 525 253	1 244 071	123 163.0
347	2.881 844	1 090 133	94 569.01	397	2.518 892	1 247 212	123 785.8
348	2.873 563	1 093.274	95 114.86	398	2.512 563	1 250 354	124 410.2
349	2.865 330	1 096.416	95 662.28	399	2.506 266	1 253.495	125.036.2

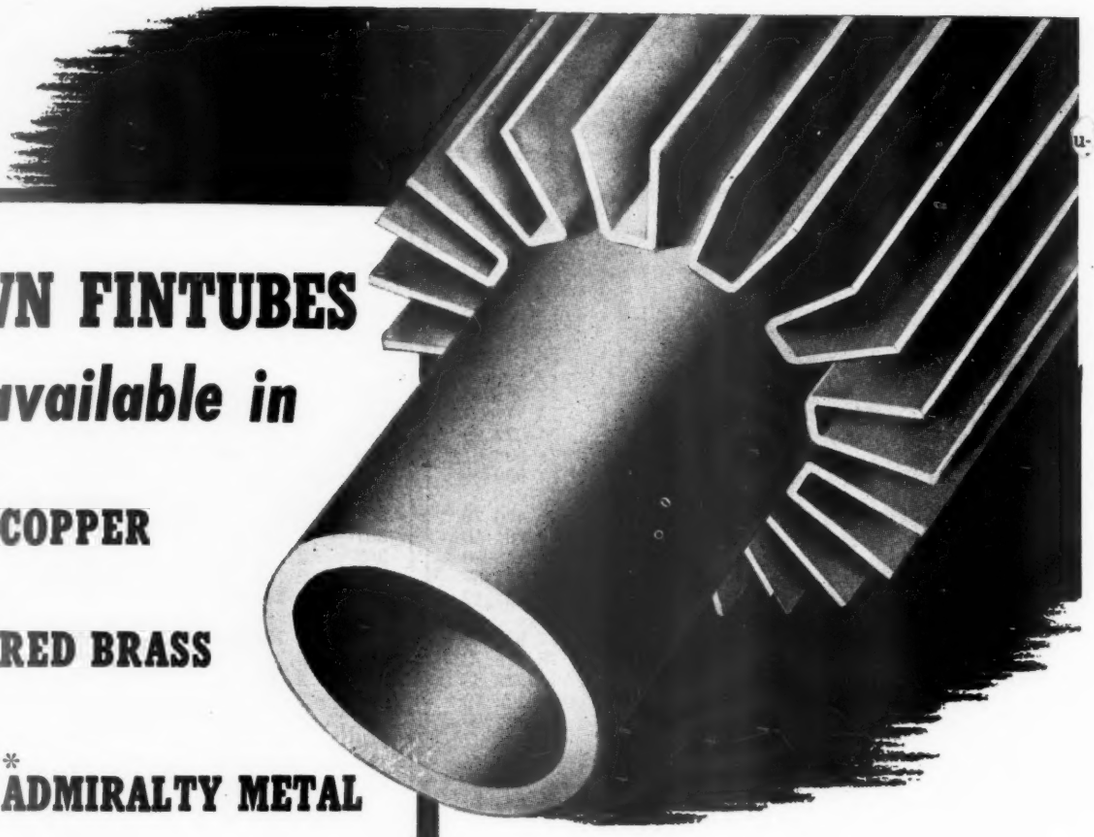
Note: n may be in any unit of measure, such as in., ft., yards, miles, meters, or fractions thereof.

Example: The diameter of a circle = 330 ft.

Then, the circumference = $330 \times \pi = 1{,}036.726$ ft. (The figure shown opposite 330); and the area = 85,529.86 sq. ft. *Notice* that the decimal point would be moved *the same number of places* to the left in pointing off for the circumference, and twice the *number of places* to the left for the area, if the circle was 33 ft. in diameter.

The *reciprocal* of a number is simply the quotient of unity (1000 is taken as unity in this table) divided by the number. It is useful in determining decimal equivalents of fractions.

Example: Opposite 320 (above), the reciprocal $\left(\frac{1000}{320}\right) = 3.125000$. Then, the decimal equivalent of the fraction 1/320 in. = 0.003125 in. And the decimal equivalent of the fraction 1/32 in. = 0.03125 in. *Notice* that the decimal point is moved *the same number* of places in the denominators of the two fractions as in the answers, but in opposite directions.



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RECIPROCALS, CIRCUMFERENCES, AND AREAS OF CIRCLES

Diam. n	Reciprocal $1000/n$	Circumference of circle πn	Area of circle $\frac{1}{4}\pi n^2$	Diam. n	Reciprocal $1000/n$	Circumference of circle πn	Area of circle $\frac{1}{4}\pi n^2$
400	2.500 000	1 256.637	125 663.7	450	2.222 222	1 413.717	159 043.1
401	2.493 766	1 259.779	126 292.8	451	2.217 295	1 416.858	159 750.8
402	2.487 562	1 262.920	126 923.5	452	2.212 389	1 420.000	160.460.0
403	2.481 390	1 266.062	127 555.7	453	2.207 506	1 423.141	161 170.8
404	2.475 248	1 269.203	128 189.5	454	2.202 643	1 426.283	161 883.1
405	2.469 136	1 272.345	128 824.9	455	2.197 802	1 429.425	162 597.1
406	2.463 054	1 275.487	129 461.9	456	2.192 982	1 432.566	163 312.6
407	2.457 002	1 278.628	130 100.4	457	2.188 184	1 435.708	164 029.6
408	2.450 980	1 281.770	130 740.5	458	2.183 406	1 438.849	164 748.3
409	2.444 988	1 284.911	131 382.2	459	2.178 649	1 441.991	165 468.5
410	2.439 024	1 288.053	132 025.4	460	2.173 913	1 445.133	166 190.3
411	2.433 090	1 291.195	132 670.2	461	2.169 197	1 448.274	166 913.6
412	2.427 184	1 294.336	133 316.6	462	2.164 502	1 451.416	167 638.5
413	2.421 308	1 297.478	133 964.6	463	2.159 827	1 454.557	168 365.0
414	2.415 459	1 300.619	134 614.1	464	2.155 172	1 457.699	169 093.1
415	2.409 639	1 303.761	135 265.2	465	2.150 538	1 460.841	169 822.7
416	2.403 846	1 306.903	135 917.9	466	2.145 923	1 463.982	170 553.9
417	2.398 082	1 310.044	136 572.1	467	2.141 328	1 467.124	171 286.7
418	2.392 344	1 313.186	137 227.9	468	2.136 752	1 470.265	172 021.0
419	2.386 635	1 316.327	137 885.3	469	2.132 196	1 473.407	172 757.0
420	2.380 952	1 319.469	138 544.2	470	2.127 660	1 476.549	173 494.5
421	2.375 297	1 322.611	139 204.8	471	2.123 142	1 479.690	174 233.5
422	2.369 668	1 325.752	139 866.8	472	2.118 644	1 482.832	174 974.1
423	2.364 066	1 328.894	140 530.5	473	2.114 165	1 485.973	175 716.3
424	2.358 491	1 332.035	141 195.7	474	2.109 705	1 489.115	176 460.1
425	2.352 941	1 335.177	141 862.5	475	2.105 263	1 492.257	177 205.5
426	2.347 418	1 338.318	142 530.9	476	2.100 840	1 495.398	177 952.4
427	2.341 920	1 341.460	143 200.9	477	2.096 436	1 498.540	178 700.9
428	2.336 449	1 344.602	143 872.4	478	2.092 050	1 501.681	179.450.9
429	2.331 002	1 347.743	144 545.5	479	2.087 683	1 504.823	180 202.5
430	2.325 581	1 350.885	145 220.1	480	2.083 333	1 507.964	180 955.7
431	2.320 186	1 354.026	145 896 3	481	2.079 002	1 511.106	181 710.5
432	2.314 815	1 357.168	146 574.1	482	2.074 689	1 514.248	182 466.8
433	2.309 469	1 360.310	147 253.5	483	2.070 393	1 517.389	183.224.8
434	2.304 147	1 363.451	147 934.5	484	2.066 116	1 520.531	183 984.2
435	2.298 851	1 366.593	148 617.0	485	2.061 856	1 523.672	184 745.3
436	2.293 578	1 369.734	149 301.0	486	2.057 613	1 526.814	185 507.9
437	2.288 330	1 372.876	149 986.7	487	2.053 388	1 529.956	186 272.1
438	2.283 105	1 376.018	150 673.9	488	2.049 180	1 533.097	187 037.9
439	2.277 904	1 379.159	151 362.7	489	2.044 990	1 536.239	187 805.2
440	2.272 727	1 382.301	152 053.1	490	2.040 816	1 539.380	188 574.1
441	2.267 574	1 385.442	152 745.0	491	2.036 660	1 542.522	189 344.6
442	2.262 443	1 388.584	153 438.5	492	2.032 520	1 545.664	190 116.6
443	2.257 336	1 391.726	154 133.6	493	2.028 398	1 548.805	190.890 2
444	2.252 252	1 394.867	154 830.3	494	2.024 291	1 551.947	191 665.4
445	2.247 191	1 398.009	155 528.5	495	2.020 202	1 555.088	192 442.2
446	2.242 152	1 401.150	156 228.3	496	2.016 129	1 558.230	193 220.5
447	2.237 136	1 404.292	156 929.6	497	2.012 072	1 561.372	194.000.4
448	2.232 143	1 407.434	157.632 6	498	2.008 032	1 564.513	194.781.9
449	2.227 171	1 410.575	158.337 1	499	2.004 008	1 567.655	195 564.9

Note: n may be in any unit of measure, such as in., ft., yards, miles, meters, or fractions thereof.

Example: The diameter of a circle = 433 ft.

Then, the circumference = $433 \times \pi = 1{,}360.310$ ft. (The figure shown opposite 433); and the area = 147,253.5 sq. ft. *Notice* that the decimal point would be moved *the same number of places* to the left in pointing off for the circumference, and twice the *number of places* to the left for the area, if the circle was 43.3 ft. in diameter.

The *reciprocal* of a number is simply the quotient of unity (1000 is taken as unity in this table) divided by the number. It is useful in determining decimal equivalents of fractions.

Example: Opposite 480 (above), the reciprocal $\left(\frac{1000}{480}\right) = 2.083333$. Then, the decimal equivalent of the fraction 1/480 in. $\doteq 0.002083333$ in. And, the decimal equivalent of the fraction 1/48 in. = 0.02083333 in. *Notice* that the decimal point is moved *the same number* of places in the denominators of the two fractions as in the answers, but in opposite directions.

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There are no mechanical complications in a Nash Compressor. A single moving element, a round rotor, with shrouded blades, forming a series of buckets, revolves freely in an elliptical casing containing any low viscosity liquid. This liquid, carried with the rotor, follows the elliptical contour of the casing.

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RECIPROCALS, CIRCUMFERENCES, AND AREAS OF CIRCLES

Diam. n	Reciprocal $1000/n$	Circumference of circle πn	Area of circle $\frac{1}{4}\pi n^2$	Diam. n	Reciprocal $1000/n$	Circumference of circle πn	Area of circle $\frac{1}{4}\pi n^2$
500	2.000 000	1 570.796	196 349.5	550	1.818 182	1 727.876	237 582.9
501	1.996 008	1 573.938	197 135.7	551	1.814 882	1 731.018	238 447.7
502	1.992 032	1 577.080	197 923.5	552	1.811 594	1 734.159	239 314.0
503	1.988 072	1 580.221	198 712.8	553	1.808 318	1 737.301	240 181.8
504	1.984 127	1 583.363	199 503.7	554	1.805 054	1 740.442	241 051.3
505	1 980 198	1 586 504	200 296.2	555	1.801 802	1 743.584	241 922.3
506	1.976 285	1 589.646	201 090.2	556	1.798 561	1 746.726	242 794.8
507	1.972 387	1 592.787	201 885.8	557	1.795 332	1 749.867	243 669.0
508	1.968 504	1 595.929	202.683.0	558	1.792 115	1 753.009	244 544.7
509	1.964 637	1 599.071	203 481.7	559	1.788 909	1 756.150	245 422.0
510	1.960 784	1 602.212	204 282.1	560	1.785 714	1 759.292	246 300.9
511	1.956 947	1 605.354	205 084.0	561	1.782 531	1 762.433	247 181.3
512	1.953 125	1 608.495	205 887.4	562	1.779 359	1 765.575	248 063.3
513	1.949 318	1 611.637	206 692.4	563	1.776 199	1 768.717	248 946.9
514	1.945 525	1 614.779	207 499.1	564	1.773 050	1 771.858	249 832.0
515	1.941 748	1 617.920	208 307.2	565	1.769 912	1 775.000	250 718.7
516	1.937 984	1 621.062	209 117.0	566	1.766 784	1 778.141	251 607.0
517	1.934 236	1 624.203	209 928.3	567	1.763 668	1 781.283	252 496.9
518	1.930 502	1 627.345	210 741.2	568	1.760 563	1 784.425	253 388.3
519	1.926 782	1 630.487	211 555.6	569	1.757 469	1 787.566	254 281 3
520	1.923 077	1 633 628	212 371.7	570	1.754 386	1 790.708	255 175.9
521	1.919 386	1 636.770	213 189.3	571	1.751 313	1 793.849	256 072.0
522	1.915 709	1 639.911	214 008.4	572	1.748 252	1 796.991	256 969.7
523	1.912 046	1 643.053	214 829.2	573	1.745 201	1 800.133	257 869.0
524	1.908 397	1 646.195	215 651.5	574	1.742 160	1 803.274	258 769.8
525	1.904 762	1 649.336	216 475.4	575	1.739 130	1 806.416	259 672.3
526	1.901 141	1 652.478	217 300.8	576	1.736 111	1 809.557	260 576.3
527	1.897 533	1 655.619	218 127.8	577	1.733 102	1 812.699	261 481.8
528	1.893 939	1 658.761	218 956 4	578	1.730 104	1 815.841	262 389.0
529	1.890 359	1 661.903	219 786.6	579	1.727 116	1 818.982	263 297.7
530	1.886 792	1 665.044	220 618.3	580	1.724 138	1 822.124	264 207.9
531	1.883 239	1 668.186	221 451.7	581	1.721 170	1 825.265	265 119.8
532	1.879 699	1 671.327	222 286.5	582	1.718 213	1 828.407	266 033.2
533	1.876 173	1 674.469	223 123.0	583	1.715 266	1 831.549	266 948.2
534	1.872 659	1 677.610	223 961.0	584	1.712 329	1 834.690	267 864.8
535	1.869 159	1 680.752	224 800.6	585	1.709 402	1 837.832	268 782.9
536	1.865 672	1 683.894	225 641.8	586	1.706 485	1 840.973	269 702.6
537	1.862 197	1 687.035	226 484.5	587	1.703 578	1 844.115	270 623.9
538	1.858 736	1 690.177	227 328.8	588	1.700 680	1 847.256	271 546.7
539	1.855 288	1 693.318	228 174.7	589	1.697 793	1 850.398	272 471.1
540	1.851 852	1 696.460	229 022.1	590	1.694 915	1 853.540	273 397.1
541	1.848 429	1 699.602	229 871.1	591	1.692 047	1.856.681	274 324.7
542	1.845 018	1 702.743	230 721.7	592	1.689 189	1 859.823	275 253.8
543	1.841 621	1 705 885	231 573.9	593	1.686 341	1 862.964	276 184.5
544	1.838 235	1 709.026	232 427.6	594	1.683 502	1 866.106	277 116.7
545	1.834 862	1 712.168	233 282.9	595	1.680 672	1 869.248	278 050.6
546	1.831 502	1 715.310	234 139.8	596	1.677 852	1 872.389	278 986.0
547	1.828 154	1 718.451	234 998.2	597	1.675 042	1 875.531	279 923.0
548	1.824 818	1 721 593	235 858.2	598	1.672 241	1 878.672	280 861.5
549	1.821 494	1 724.734	236 719.8	599	1.669 449	1 881.814	281 801.6

Note: n may be in any unit of measure, such as in., ft., yards, miles, meters, or fractions thereof.

Example: the diameter of a circle = 5.5 in.

Then, the circumference = $5.5 \times \pi = 17.27876$ in. (The figure shown opposite 550 pointed off for the fraction); and the area = 23.75829 sq. in. *Notice* that the decimal point is moved *the same number of places* to the left in pointing off for the circumference, and twice the *number of places* to the left for the area.

The *reciprocal* of a number is simply the quotient of unity (1000 is taken as unity in this table) divided by the number. It is useful in determining decimal equivalents of fractions.

Example: Opposite 560 (above), the reciprocal $\left(\frac{1000}{560}\right) = 1.785714$. Then, the decimal equivalent of the fraction 1/560 in. = 0.001785714 in. And, the decimal equivalent of the fraction 1/56 in. = 0.01785714 in. *Notice* that the decimal point is moved *the same number* of places in the denominators of the two fractions as in the answers, but in opposite directions.

*the Drilling Supt.**

Ask about pressure gauges

HE knows what a pressure gauge is up against. As one drilling superintendent put it: "What puzzles me is how Marsh has managed to turn out a gauge that can stand so much vibration and pressure surge . . . and still *stay* right!"

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Yes, in the Marsh Mastergauge you have an instrument made for the oil industry's tough grind—a gauge with a lathe-turned and reamed bourdon tube—a gauge with an advanced monel and stainless steel movement—a gauge that is vapor-proof, moisture-proof, trouble-proof. If it is ever knocked out of adjustment (which you won't find easy to do) the Marsh "Recalibrator" enables you to readjust it in a jiffy right in the field.

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The Marsh branch plant at Houston means prompt shipment from a complete stock and facilities for repairing all makes of gauges.

MARSH GAUGES

*One of a series of advertisements dedicated to key men in the petroleum industry

RECIPROCALS, CIRCUMFERENCES, AND AREAS OF CIRCLES

Diam. n	Reciprocal $1000/n$	Circumference of circle πn	Area of circle $\frac{1}{4}\pi n^2$	Diam. n	Reciprocal $1000/n$	Circumference of circle πn	Area of circle $\frac{1}{4}\pi n^2$
600	1.666 667	1 884.956	282 743.3	650	1.538 462	2 042.035	331 830.7
601	1.663 894	1 888.097	283 686.6	651	1.536 098	2 045.177	332 852.5
602	1.661 130	1 891.239	284 631.4	652	1.533 742	2 048.318	333 875.9
603	1.658 375	1 894.380	285 577.8	653	1.531 394	2 051.460	334 900.8
604	1.655 629	1 897.522	286 525.8	654	1.529 052	2 054.602	335 927.4
605	1.652 893	1 900.664	287 475.4	655	1.526 718	2 057.743	336 955.4
606	1.650 165	1 903.805	288 426.5	656	1.524 390	2 060.885	337 985.1
607	1.647 446	1 906.947	289 379.2	657	1.522 070	2 064.026	339 016.3
608	1.644 737	1 910.088	290 333.4	658	1.519 757	2 067.168	340 049.1
609	1.642 036	1 913.230	291 289.3	659	1.517 451	2 070.310	341 083.5
610	1.639 344	1 916.372	292 246.7	660	1.515 152	2 073.451	342 119.4
611	1.636 661	1 919.513	293 205.6	661	1.512 859	2 076.593	343 157.0
612	1.633 987	1 922.655	294 166.2	662	1.510 574	2 079.734	344 196.0
613	1.631 321	1 925.796	295 128.3	663	1.508 296	2 082.876	345 236.7
614	1.628 664	1 928.938	296 092.0	664	1.506 024	2 086.018	346 278.9
615	1.626 016	1 932.079	297 057.2	665	1.503 759	2 089.159	347 322.7
616	1.623 377	1 935.221	298 024.0	666	1.501 502	2 092.301	348 368.1
617	1.620 746	1 938.363	298 992.4	667	1.499 250	2 095.442	349 415.0
618	1.618 123	1 941.504	299 962.4	668	1.497 006	2 098.584	350 463.5
619	1.615 509	1 944.646	300 933.9	669	1.494 768	2 101.725	351 513.6
620	1.612 903	1 947.787	301 907.1	670	1.492 537	2 104.867	352 565.2
621	1.610 306	1 950.929	302 881.7	671	1.490 313	2 108.009	353 618.5
622	1.607 717	1 954.071	303 858.0	672	1.488 095	2 111.150	354 673.2
623	1.605 136	1 957.212	304 835.8	673	1.485 884	2 114.292	355 729.6
624	1.602 564	1 960.354	305 815.2	674	1.483 680	2 117.433	356 787.5
625	1.600 000	1 963.495	306 796.2	675	1.481 481	2 120.575	357 847.0
626	1.597 444	1 966.637	307 778.7	676	1.479 290	2 123.717	358 908.1
627	1.594 896	1 969.779	308 762.8	677	1.477 105	2 126.858	359 970.8
628	1.592 357	1 972.920	309 748.5	678	1.474 926	2 130.000	361 035.0
629	1.589 825	1 976.062	310 735.7	679	1.472 754	2 133.141	362 100.8
630	1.587 302	1 979.203	311 724.5	680	1.470 588	2 136.283	363 168.1
631	1.584 786	1 982.345	312 714.9	681	1.468 429	2 139.425	364 237.0
632	1.582 278	1 985.487	313 706.9	682	1.466 276	2 142.566	365 307.5
633	1.579 779	1 988.628	314 700.4	683	1.464 129	2 145.708	366 379.6
634	1.577 287	1 991.770	315 695.5	684	1.461 988	2 148.849	367 453.2
635	1.574 803	1 994.911	316 692.2	685	1.459 854	2 151.991	368 528.5
636	1.572 327	1 998.053	317 690.4	686	1.457 726	2 155.133	369 605.2
637	1.569 859	2 001.195	318 690.2	687	1.455 604	2 158.274	370 683.6
638	1.567 398	2 004.336	319 691.6	688	1.453 488	2 161.416	371 763.5
639	1.564 945	2 007.478	320 694.6	689	1.451 379	2 164.557	372 845.0
640	1.562 500	2 010.619	321 699.1	690	1.449 275	2 167.699	373 928.1
641	1.560 062	2 013.761	322 705.2	691	1.447 178	2 170.841	375 012.7
642	1.557 632	2 016.902	323 712.8	692	1.445 087	2 173.982	376 098.9
643	1.555 210	2 020.044	324 722.1	693	1.443 001	2 177.124	377 186.7
644	1.552 795	2 023.186	325 732.9	694	1.440 922	2 180.265	378 276.0
645	1.550 388	2 026.327	326 745.3	695	1.438 849	2 183.407	379 366.9
646	1.547 988	2 029.469	327 759.2	696	1.436 782	2 186.548	380 459.4
647	1.545 595	2 032.610	328 774.7	697	1.434 720	2 189.690	381 553.5
648	1.543 210	2 035.752	329 791.8	698	1.432 665	2 192.832	382 649.1
649	1.540 832	2 038.894	330 810.5	699	1.430 615	2 195.973	383 746.3

Note: n may be in any unit of measure, such as in., ft., yards, miles, meters, or fractions thereof.

Example: The diameter of a circle = 660 ft.

Then, the circumference = $660 \times \pi = 2{,}073{,}451$ ft. (The figure shown opposite 660); and the area = 342,119.4 sq. ft. *Notice* that the decimal point would be moved the *same number of places* to the left in pointing off for the circumference, and twice the *number of places* to the left for the area, if the circle was 66 ft. in diameter.

The *reciprocal* of a number is simply the quotient of unity (1000 is taken as unity in this table) divided by the number. It is useful in determining decimal equivalents of fractions.

Example: Opposite 640 (above), the reciprocal $\left(\frac{1000}{640}\right) = 1.562500$. Then, the decimal equivalent of the fraction 1/640 in. = 0.0015625 in. And, the decimal equivalent of the fraction 1/64 in. = 0.015625 in. *Notice* that the decimal point is moved *the same number* of places in the denominators of the two fractions as in the answers, but in opposite directions.

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...valves for *every* service in *every** REFINERY PROCESS

***When special valves are required, Powell makes them.**

100 YEARS ago Powell began making valves for industry and today. a century of practical experience and continual scientific research lies behind every Powell Valve.

Some years ago, Powell Engineers started to develop a complete line of valves to meet every requirement of the modern refinery. Today this Line includes not only Bronze and Iron Valves for intermediate steam, oil, water and gas lines, but also a complete line of valves in Cast Steel and all necessary Corrosion-resistant Alloys for Cracking, Isomerization, Alkylation, Hydrogenation, Polymerization, T. C. C. and all other Catalytic processes. This includes many specially adapted patterns and a number of valves specially designed to meet specific demands.

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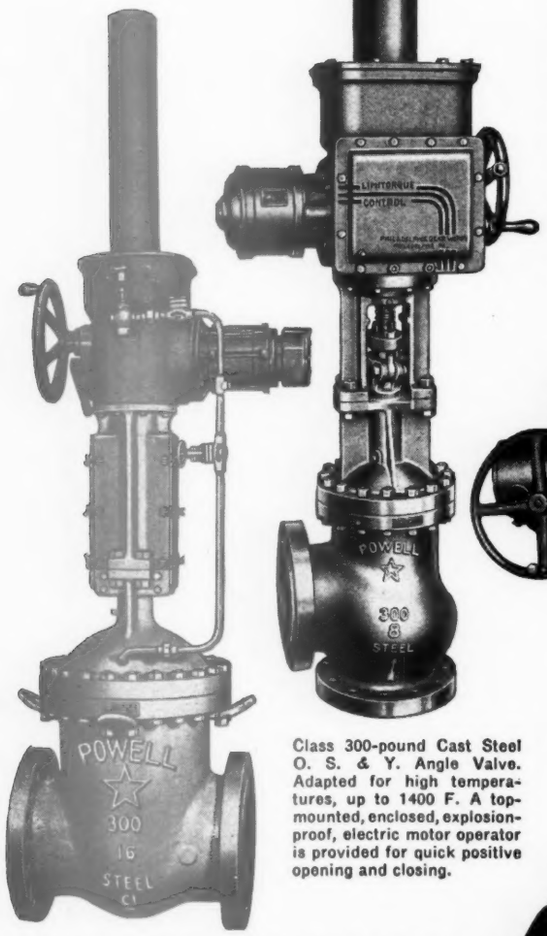
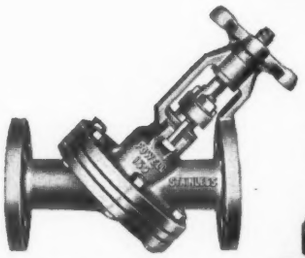


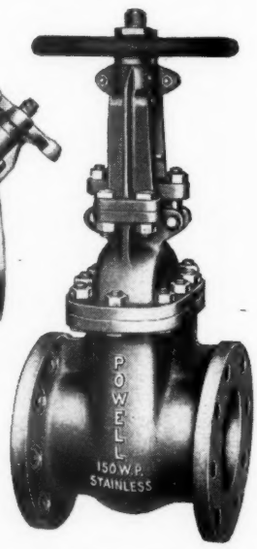
Class 300-pound Cast Steel O. S. & Y. Angle Valve. Adapted for high temperatures, up to 1400 F. A top-mounted, enclosed, explosion-proof, electric motor operator is provided for quick positive opening and closing.

Class 300-pound, 16" Cast Steel Gate Valve, specially designed for producing 100 octane aviation gasoline. Has automatic steam sealing mechanism and top-mounted, enclosed, explosion-proof, electric motor operator.

Class 300-pound Cast Alloy Steel Gate Valve, designed to meet special requirements and to handle high temperatures. Has 12" port size venturied to 20" size end flanges to accommodate insulated pipe. Also top-mounted, enclosed, explosion-proof, electric motor operator.



150-pound Stainless Steel Separable Body, Reversible Seat "Y" Valve. Lower half of body can be unbolted and turned through an arc of 180 degrees to make a 90-degree angle valve.



150-pound Stainless Steel, Flanged End, O. S. & Y. Gate Valve.

POWELL VALVES

RECIPROCALS, CIRCUMFERENCES, AND AREAS OF CIRCLES

Diam. n	Reciprocal $1000/n$	Circumference of circle πn	Area of circle $\frac{1}{4}\pi n^2$	Diam. n	Reciprocal $1000/n$	Circumference of circle πn	Area of circle $\frac{1}{4}\pi n^2$
700	1.428 571	2 199.115	384 845.1	750	1.333 333	2 356.194	441 786.5
701	1.426 534	2 202.256	385 945.4	751	1.331 558	2 359.336	442 965.3
702	1.424 501	2 205.398	387 047.4	752	1.329 787	2 362.478	444 145.8
703	1.422 475	2 208.540	388 150.8	753	1.328 021	2 365.619	445 327.8
704	1.420 455	2 211.681	389 255.9	754	1.326 260	2 368.761	446 511.4
705	1.418 440	2 214 823	390 362.5	755	1.324 503	2 371.902	447 696.6
706	1.416 431	2 217.964	391 470.7	756	1.322 751	2 375.044	448 883.3
707	1.414 427	2 221.106	392 580.5	757	1.321 004	2 378.186	450 071.6
708	1.412 429	2 224.248	393 691.8	758	1.319 261	2 381.327	451 261.5
709	1.410 437	2 227.389	394 804.7	759	1.317 523	2 384.469	452 453.0
710	1.408 451	2 230.531	395 919.2	760	1.315 789	2 387.610	453 646.0
711	1.406 470	2 233 672	397 035.3	761	1.314 060	2 390.752	454 840.6
712	1.404 494	2 236.814	398 152.9	762	1.312 336	2 393.894	456 036.7
713	1.402 525	2 239.956	399 272.1	763	1.310 616	2 397.035	457 234.5
714	1.400 560	2 243.097	400 392.8	764	1.308 901	2 400.177	458 433.8
715	1.398 601	2 246.239	401 515.2	765	1.307 190	2 403.318	459 634.6
716	1.396 643	2 249.380	402 639.1	766	1.305 483	2 406.460	460 837.1
717	1.394 700	2 252.522	403 764.6	767	1.303 781	2 409.602	462 041.1
718	1 392 758	2 255.664	404 891.6	768	1.302 083	2 412.743	463 246.7
719	1.390 821	2 258.805	406 020.2	769	1.300 390	2 415.885	464 453.8
720	1.388 889	2 261.947	407 150.4	770	1.298 701	2 419.026	465 662.6
721	1.386 963	2 265.088	408 282.2	771	1.297 017	2 422.168	466 872.9
722	1.385 042	2 268 230	409 415.5	772	1.295 337	2 425.310	468 084.7
723	1.383 126	2 271.371	410 550.4	773	1.293 661	2 428.451	469 298.2
724	1.381 215	2 274.513	411 686.9	774	1.291 990	2 431.593	470 513.2
725	1.379 310	2 277.655	412 824.9	775	1.290 323	2 434.734	471 729.8
726	1.377 410	2 280.796	413 964.5	776	1.288 660	2 437.876	472 947.9
727	1.375 516	2 283.938	415 105.7	777	1.287 001	2 441.017	474 167.6
728	1.373 626	2 287.079	416 248.5	778	1.285 347	2 444.159	475 388.9
729	1.371 742	2 290.221	417 392.8	779	1.283 697	2 447.301	476 611.8
730	1.369 863	2 293.363	418 538.7	780	1.282 051	2 450.442	477 836.2
731	1.367 989	2 296.504	419 686.1	781	1.280 410	2 453.584	479 062.2
732	1.366 120	2 299.646	420 835.2	782	1.278 772	2 456.725	480 289.8
733	1.364 256	2 302.787	421 985.8	783	1.277 139	2 459.867	481 519.0
734	1.362 398	2 305.929	423 238.0	784	1.275 510	2 463.009	482 749.7
735	1.360 544	2 309.071	424 291.7	785	1.273 885	2 466.150	483 982.0
736	1.358 696	2 312.212	425 447.0	786	1.272 265	2 469.292	485 515.8
737	1.356 852	2 315.354	426 603.9	787	1.270 648	2 472.433	486 451.3
738	1.355 014	2 318.495	427 762.4	788	1.269 036	2 475.575	487 688.3
739	1.353 180	2 321.637	428 922.4	789	1.267 427	2 478.717	488 926.9
740	1.351 351	2 324.779	430 084.0	790	1.265 823	2 481.858	490 167.0
741	1.349 528	2 327.920	431 247.2	791	1.264 223	2 485.000	491 408.7
742	1.347 709	2 331.062	432 412.0	792	1.262 626	2 488.141	492 652.0
743	1.345 895	2 334.203	433 578.3	793	1.261 034	2 491.283	493 896.8
744	1.344 086	2 337.345	434 746.2	794	1.259 446	2 494.425	495 143.3
745	1.342 282	2 340.487	435 915.6	795	1.257 862	2 497.566	496 391.3
746	1.340 483	2 343.628	437 086.6	796	1.256 281	2 500.708	497 640.8
747	1.338 688	2 346.770	438 259.2	797	1.254 705	2 503.849	498 892.0
748	1.336 898	2 349.911	439 433.4	798	1.253 133	2 506.991	500 144.7
749	1.335 113	2 353.053	440 609.2	799	1.251 564	2 510.133	501 339.0

Note: n may be in any unit of measure, such as in., ft., yards, miles, meters, or fractions thereof.

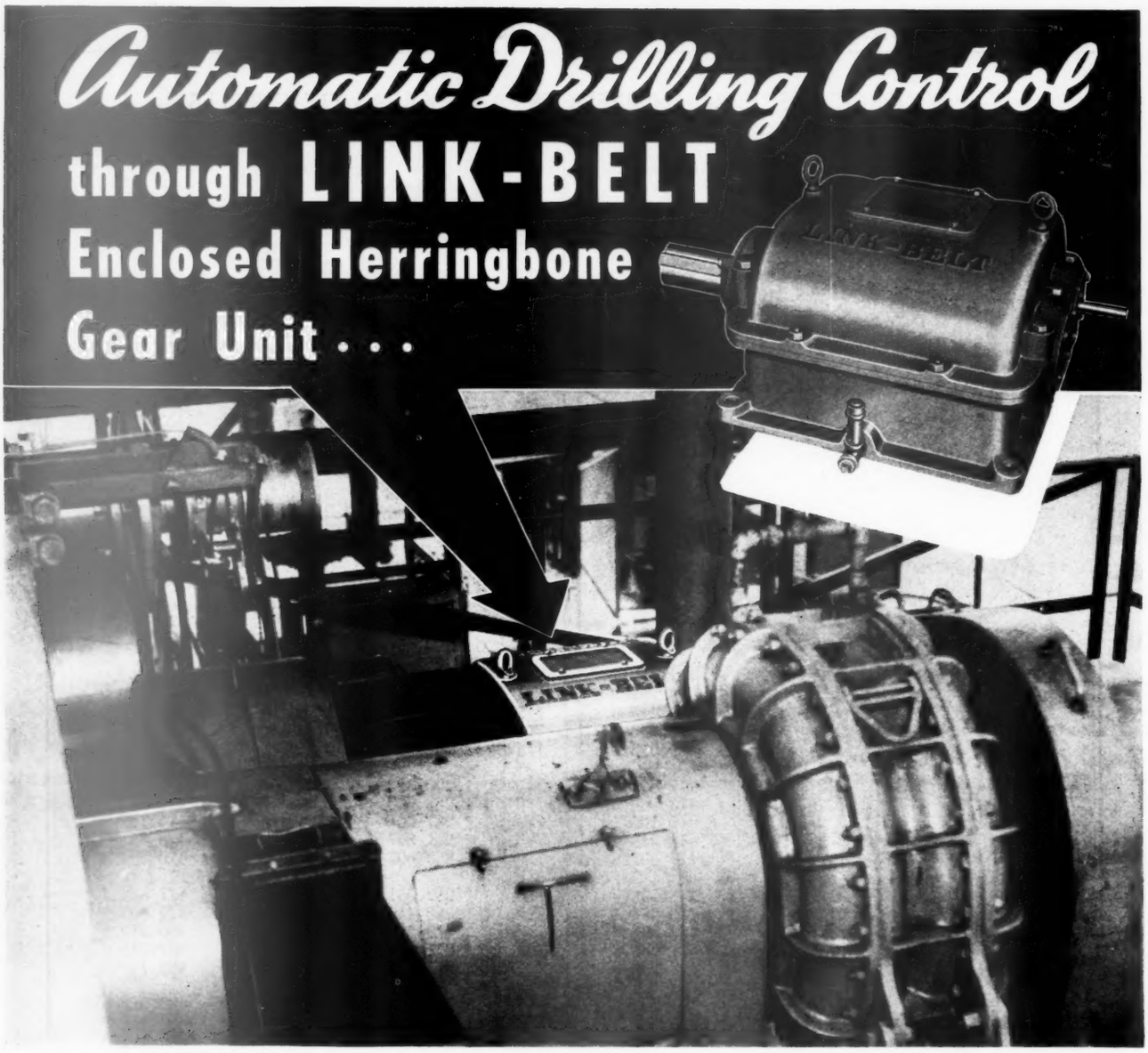
Example: The diameter of a circle = 78 ft.

Then, the circumference $= 78 \times \pi = 245\,0442$ ft. (The figure shown opposite 780 pointed off for the fraction); and the area = 4.778.362 sq. ft. *Notice* that the decimal point is moved *the same number of places* to the left in pointing off for the circumference, and twice the *number of places* to the left for the area.

The *reciprocal* of a number is simply the quotient of unity (1000 is taken as unity in this table) divided by the number. It is useful in determining decimal equivalents of fractions.

Example: Opposite 720 (above), the reciprocal $\left(\frac{1000}{720}\right) = 1.388889$. Then, the decimal equivalent of the fraction 1/720 in. = 0.001388889 in. And, the decimal equivalent of the fraction 1/72 in. = 0.01388889 in. *Notice* that the decimal point is moved *the same number* of places in the denominators of the two fractions as in the answers, but in opposite directions.

Automatic Drilling Control through LINK-BELT Enclosed Herringbone Gear Unit . . .



A new application of Link-Belt's enclosed herringbone gear unit is proving this product's value as an aid to rotary drilling progress.

On a major deep well project, pictured above, a Link-Belt Type T-12 enclosed herringbone gear unit, serving as a speed increaser, is serving as a vital part of an automatic drilling control mechanism used to regulate the feed-off of the drilling line. The increaser has three gear sets with a ratio of 302.2:1 and is provided with a special tapered, threaded high speed output shaft for use in connection with an air actuated disc type brake which is operated by controls connected with the dead line. The input shaft of the gear increaser has a 20-tooth 2" pitch double width sprocket connected to a 54-tooth sprocket on the drum shaft. Through use of this chain drive, the total ratio is stepped up to 815.4 to 1 from the output shaft of the gear unit to the drawworks drum shaft.

Increasing of the output shaft speed permits the use of a precision high speed brake which, in turn, permits more accuracy and sensitivity, and therefore better drilling control. This is because a low torque, or brake power, on the high speed shaft can hold 816 times its load on the drum shaft. At a rate of one foot per hour of bit feed the high speed brake shaft is turning about 13.5 r.p.m.

Details of this and other oil industry applications of Link-Belt Speed Increasers and Reducers will be furnished upon request.

LINK-BELT COMPANY

Indianapolis 6, Dallas 1, Houston 2, Los Angeles 33, Kansas City 6, Mo., New York 7, Toronto 8.

10.187

LINK-BELT SPEED REDUCERS

Land and Lease Negotiation

Man capable of obtaining land permits and negotiating oil land leases for oil company in Venezuela. Must have thorough knowledge of Spanish and be familiar with Latin American people. Salary, depending on training and experience, to range from $600.00 to $750.00 a month plus living allowance. Please write full particulars to T-13, P. O. Box 3414, Philadelphia 22, Pennsylvania.

POSITION WANTED AS SALES REPRESENTATIVE FOR ASPHALTS AND ROAD OILS in the State of Wisconsin. Have had several years experience in the BITUMINOUS Road construction business. Address Box 43, c/o *The Petroleum Engineer*, P. O. Box 1589, Dallas, Texas.

ENGINEERS WANTED

An oil field service organization has openings for engineers in technical oil field service. Men with one or two years experience in oil production and degree in Petroleum, Electrical or Mechanical Engineering are given preference. Permanent position with long established company. Write giving full details on education, experience, age and marital status. Attach small photograph. Address replies to Box 38, care of *The Petroleum Engineer*, P. O. Box 1589, Dallas, Texas.

WANTED: Sales Engineer by oilfield engine distributor. Engineering graduate with thorough knowledge of East Texas oil field. Address Box No. 44, c/o *The Petroleum Engineer*, P. O. Box 1589, Dallas, Texas.

WANTED—District sales manager water treating and process equipment for liquids. Must be familiar with these lines and have held similar positions. Location, New York City. Write, giving experience, education, age, companies worked for, references, positions held, salary expected, etc. Address Box 41, care *The Petroleum Engineer*, P. O. Box 1589 ,Dallas, Texas.

Management changes

Two major changes in the management personnel of American Steel and Wire Company, a U. S. Steel Corporation subsidiary, have been announced by C. F. Hood, president.

John May, vice president in charge of sales, has been appointed assistant to the president to aid in general commercial and sales policies. May is succeeded by Harry M. Francis, who has been elected vice president in charge of sales. Francis has been assistant vice president.

May and Francis are two of the best known figures in the steel and wire industry. May's service with the wire company dates back to February, 1909.

Francis entered the employ of the American Steel and Wire Company as a messenger in the New York office in 1915. Francis saw ten months' service in the Navy in World War I. During World War II, Francis also was in government service with the War Production Board.

District manager

Arthur J. Olson, heretofore district sales engineer for Link-Belt Company at Chicago, has been appointed district sales manager at Kansas City, Missouri, to succeed Max Giffey, who has resigned after 40 years' service with the company.

Olson has been in the employ of Link-Belt Company since 1918, at the Pershing Road plant in Chicago.

Research project

Establishment in Chicago of a manufacturing research project devoted to the improvement of manufacturing methods and procedures for the entire line of International Harvester Company products, is announced by K. O. Schreiber, vice president in charge of manufacturing. The company's manufacturing research activities will be carried on in the plant operated during the war by Foote Bros. Gear and Machine Corporation for the manufacture of aviation parts, at 5225 South Western Avenue. The Harvester project will occupy about 230,000 sq. feet of floor space and the company will invest a substantial sum of money in the improvement of the property and in the procurement of necessary equipment and facilities.

This new J-M machine
DOUBLE COATS and DOUBLE WRAPS
in one operation!

This machine was especially developed for J-M by Crutcher-Rolfs-Cummings of Houston.

Here's the way to get "plus" protection for your pipelines in double-quick time!

THIS ingenious J-M machine alternately applies *two* layers of Johns-Manville Asbestos Felts and *two* coats of enamel to give protection against severe corrosive conditions.

Pioneers in the manufacture and application of asbestos wrappings . . . Johns-Manville has gone a step further with this new machine.

The J-M Coating and Wrapping Machine can save time and money for you, just as J-M Asbestos Pipeline Felts safeguard the enamel on your lines against soil stress and distortion. For further information, write Johns-Manville, 22 East 40th Street, New York 16, N. Y.

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville *Asbestos* Pipeline Felts

Personnel changes

Announcement has been made by The Continental Supply Company of 4 personnel changes effective March 1.

C. N. Swanson has been appointed to the position of director of purchases, succeeding R. L. Middleton, resigned. He will be connected with the company's general offices in Dallas.

Swanson joined the Continental organization in November, 1916. He was employed in various stores in Oklahoma, being store manager at Apperson from December, 1921, until February, 1923, when he took over management of the Tulsa store. He remained in that capacity only several months, being appointed assistant district manager at Okmulgee in May of the same year.

In September, 1930, Swanson assumed the same duties in Midland, Texas, and later held the same capacity in Arp and Longview, Texas, until March, 1936. At that time he was named district manager at Tulsa, holding that position until this time.

R. A. Brewer, newly named district manager of the Kansas-Oklahoma district, became connected with the Continental organization in August, 1920, and served in various capacities in Oklahoma and Louisiana until January, 1929, when he was appointed assistant district manager, Shreveport. In September, 1930, he moved to Fort Worth as assistant district manager. He was made district manager in Fort Worth 9 years later.

C. N. Swanson

R. A. Brewer

T. D. Collins succeeds to management of the North and West Texas-New Mexico district. Joining Continental in 1926, Collins was made manager of the Ranger, Texas, store in 1932. Subsequently he was employed at Luling, Breckenridge, and McCamey, Texas, and Hobbs, New Mexico, being store manager at the last three points. In 1938 Collins was appointed assistant district manager at Odessa, remaining there until 1943 when he was made district manager at Casper, Wyoming.

T. D. Collins

J. R. Chapman

J. R. Chapman became identified with Continental in 1925. He served in several capacities in Oklahoma. In 1936, Chapman was appointed assistant district manager, Oklahoma City, remaining there until his appointment at this time to district manager of the Rocky Mountain district.

New representative

John S. Chick of Tulsa, Oklahoma, has been appointed representative in the Mid-Continent area for Oshkosh Motor Trucks, Inc., of Oshkosh, Wisconsin, according to J. S. Mosling, president. Chick is a graduate engineer from Cornell and has spent 15 years in the oil country in production and drilling, petroleum engineering, and sales and service engineering with Skelly, Shell, and Carter oil companies, and Baker Oil Tools, Inc., of Los Angeles. Chick will have his headquarters in Tulsa.

John S. Chick

SPECIFY
SPANG
FOR THE BEST IN CABLE TOOLS
SPANG
TRIP SPEAR
(Fig. F501)
REVERSIBLE RIPPER
(Fig. F515)
Fig. F501
Fig. F515
THE HIGHER STANDARD
FOR CASING FISHING JOBS Spang offers a variety of tools including Casing Cutter; Casing Splitter; Out of Collar Ripper (F515); Swage; Bell Socket; Bull Dog Spear; and Trip Spear (F501).
All are made of the best materials obtainable and carefully designed for the work for which they are intended.
For the best in Cable Tools,
SPECIFY SPANG
SPANG & CO.
BUTLER, PA.
YOUR DEALER SELLS SPANG TOOLS

PRODUCERS OF LIQUEFIED PETROLEUM GASES*

Compiled by **A. T. COUMBE,** Petroleum Economics Division, Economics and Statistics Branch,

United States Department of the Interior, Bureau of Mines

J. S. Abercrombie Company and Magnolia Petroleum Company, 215 Gulf Building, Houston 2, Texas.
American Liberty Oil Company. Box 56, Grapeland, Texas.
Anchor Gasoline Corporation, Atlas Life Building, Tulsa 3, Oklahoma.
Aqua Dulce Company, The., Suite 2202-4, Alamo National Bank Building, San Antonio, Texas.
Arkansas Fuel Oil Company, Slattery Building, Shreveport, Louisiana.
Arkla Oil Corporation, Box 2519, Dallas, Texas.
Bankline Oil Company, 437 S. Hill Street, Los Angeles 13, Calif.
Barnsdall Oil Company, Gas and Gasoline Division, Petroleum Building, Tulsa, Oklahoma.
Belridge Oil Company, 815 Edison Building, Los Angeles 13, California.
Cabot Carbon Company, 77 Franklin Street, Boston, Massachusetts.
Cannon Gasoline Company, P. O. Box 966, Amarillo, Texas.
Carbide and Carbon Chemicals Corporation, Pyrofax Gas Division, 30 E. 42nd Street, New York 17, New York.
Carter Oil Company, Box 801, Tulsa, Oklahoma.
Chicago Corporation, P. O. Box 1702, Corpus Christi, Texas.
Cimarron Gasoline Corporation, Coyle, Oklahoma.
Cities Service Oil Company, Bartlesville, Oklahoma.
Claiborne Gasoline Company, Lisbon, Louisiana.
Coastal Refineries, Inc., Taylor, Texas.
Coline Gasoline Corporation, 108 W. 6th Street, Los Angeles 13, California.
Colonial Beacon Oil Company, 30 Beacham Street, Everett, Massachusetts.
Coltexo Corporation, 605 Ouachita National Bank Building, Monroe, Louisiana.
Col-Tex Refining Company, Colorado City, Texas.
Columbian Carbon Company, 41 East 42nd Street, New York, New York.
Continental Oil Company, Natural Gasoline and Gas Division, Ponca City, Oklahoma.
Cotton Valley Operators Committee, Cotton Valley, Louisiana.
Cowan Oil & Refining Company, 534 Bartlett Building, Los Angeles 14, California.
Crosbie, Inc., J. E., 1810 National Bank of Tulsa Building, Tulsa 2, Oklahoma.
Cumberland Gasoline Corporation, 14717 Detroit Avenue, Lakewood 7, Ohio.
Danciger Oil and Refining Company, W. T. Waggoner Building, Fort Worth, Texas.
Deep Oil Development Company, The, 201 City National Building, Wichita Falls, Texas.
Deep Rock Oil Corporation, Cushing, Oklahoma.
Del Rey Petroleum Company, Hardin, Texas.
Del Valle Gasoline Company, 811 W. 7th Street, Los Angeles 14, California.
Devonian Oil Company, Box 1379, Tulsa, Oklahoma.
Distillate Production Corporation, 1414 Niels Esperson Building, Houston 2, Texas.
Duval Gasoline Company, Box 2166, Corpus Christi, Texas.
El Paso Natural Gas Company, P. O. Box 1492, El Paso, Texas.
Fullerton Oil Company, 944 Wilshire Boulevard, Los Angeles 14, California.
Gas-Oil Products, Inc., 45 S. 3rd Street, Oxford, Pennsylvania.
Geier-Jackson Recycling Company, Grapeland, Texas.
General Petroleum Corporation of California, 1003 Higgins Building, Los Angeles 12, California.
Glen Rose Gasoline Company, The, Rodessa, Louisiana.
Great Southern Corporation, Corpus Christi, Texas.
O. H. Grimes, Box 327, Tulsa, Oklahoma.
Gulf Oil Corporation, Production Division, Drawer 2100, Houston 1, Texas.
Gulf Plains Corporation, P. O. Box 1702, Corpus Christi, Texas.
Hagy, Harrington and Marsh, 801 Amarillo Building, Amarillo, Texas.
Hamman Oil and Refining Company, 2131 San Felipe Road, Houston, Texas.
Highlander Gasoline Company, Box 480, Nocona, Texas.
Hope Construction and Refining Company, 545 William Penn Way, Pittsburgh, Pennsylvania.
Hope Natural Gas Company, P. O. Box, 1951, Clarksburg, West Virginia.
Humble Oil and Refining Company, Houston, Texas.
Hunt Oil Company, 1610 Cotton Exchange Building, Dallas 1, Texas.
Inland Refining Company, Drawer 652, Palestine, Texas
Keener Oil and Gas Company, The, 406 National Bank of Tulsa Building, Tulsa 2, Oklahoma.
La Gloria Corporation, Corpus Christi, Texas.
Lion Oil Refining Company, Exchange Building, El Dorado, Arkansas.
Lockhart Oil Company, 2000 Milam Building, San Antonio, Texas.
Lomita Gasoline Company, Box 851, Long Beach, California.
Lone Star Producing Company, 1915 Wood Street, Dallas, Texas.
Los Nietos Producing and Refining Company, 714 W. Olympic Boulevard, Los Angeles 15, California.
Magruder, P. S., Operator, Western States Gasoline Plant, 108 W. Second Street, Los Angeles 12, California.
Maljamar Cooperative Repressuring Agreement, Artesia, New Mexico.
Mars Company, The., 308 Seneca Street, Oil City, Pennsylvania.
Mid-Continent Petroleum Corporation, 1206 Mid-Continent Building, Tulsa, Oklahoma.
Midland Gasoline Company, Box 338, Conroe, Texas.
Nash Gasoline Company, Graham, Texas.
Natural Gasoline Corporation, Box 1589, Tulsa, Oklahoma.
Norwalk Company, 437 S. Hill Street, Los Angeles 13, California.
Ohio Oil Company, Findlay, Ohio.
Owens-Libby-Owens, Gas Department, Box 2111, Charleston, West Virginia.
Paloma Cycling Plant, P. O. Box 471, Bakersfield, California.
Pan American Petroleum Corporation, Texas City, Texas.
Parade Company, The, 1308 Commercial National Bank Building, Shreveport, Louisiana.
Peppers Gasoline Company, P. O. Box 86, Oklahoma City, Oklahoma.
Phillips Petroleum Company, Chemical Products Department, Bartlesville, Oklahoma.
Portland Gasoline Company, Pampa, Texas.
Pure Oil Company, The, Gasoline Division, 35 E. Wacker Drive, Chicago, Illinois.
Richfield Oil Corporation, 555 S. Flower Street, Los Angeles 13, California.
Sabine Valley Gasoline Company, Inc., 525 First National Bank Building, Shreveport 23, Louisiana.
Shamrock Oil and Gasoline Corporation, The, Amarillo Building, Amarillo, Texas.
Shell Oil Company, Inc., Shell Building, San Francisco 6, California.
Shell Oil Company, Inc., (East of the Rockies territory), 50 W. 50th Street, New York 20, New York.
Shuler Unit Natural Gasoline Plant, c/o Lion Oil Refining Company, El Dorado, Arkansas.
Signal Oil and Gas Company, 811 West

*Reporting to the Bureau of Mines.

Note.—Producers of liquefied petroleum gases may have their names added to this list on request.

Now available – an

ELECTRONIC VOLTMETER

BATTERY OPERATED

THIS MODEL 302

Sensitive Electronic Voltmeter is a new battery operated version of the standard Model 300 A.C. operated voltmeter. Operates from lightweight batteries contained within the carrying case.

MODEL 300
AC operated

Incorporating the popular single logarithmic voltage scale and uniform decibel scale, the Model 302 battery operated instrument retains all of the desirable features and performance of the standard Model 300 AC operated voltmeter illustrated at the left.

Voltage Range=.001 to 100 volts
Frequency=5 to 150,000 cycles
Accuracy=2% at any point on scale

The Model 302 Voltmeter will be found useful where A.C. supply is not available, as for example in airplanes, boats, automobiles, in the field, etc. Also valuable for making measurements on ungrounded and symmetrical circuits. Batteries meet JAN specifications.

Send for Bulletin for further description

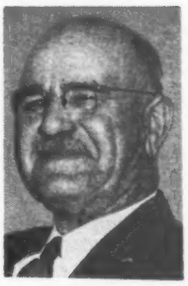
BALLANTINE LABORATORIES, INC.

BOONTON, NEW JERSEY, U. S. A.

Seventh Street, Los Angeles 14, California.
Sinclair Prairie Oil Company, Sinclair Building, Tulsa, Oklahoma.
Sinclair Refining Company, Houston, Texas.
Skelly Oil Company, P. O. Box 1650, Tulsa, Oklahoma.
Skinner and Eddy Corporation, Schallert Building, Alice, Texas.
Sloan and Zook Company, The, Kane Division, Kane, Pennsylvania.
Smith Brothers Refining Corporation, Sinton, Texas.
Socony-Vacuum Oil Company, Inc., 26 Broadway, New York 4, New York.
Southern Minerals Corporation, Corpus Christi, Texas.
Southport Petroleum Company of Delaware, Texas City, Texas.
Standard Oil Company of California, 225 Bush Street, San Francisco 20, California.
Standard Oil Company of New Jersey, Liquefied Gas Division, 26 Broadway, New York, New York.
Standard Oil Company (Ohio), Liquefied Gas Department, Midland Building, Cleveland, Ohio.
Standard Oil Company of Texas, P. O. Box 862, El Paso, Texas.
Stanolind Oil and Gas Company, Stanolind Building, Tulsa 2, Oklahoma.
Sunflower Petroleum Products Corporation, Salem, Illinois.
Sun Oil Company, 1608 Walnut Street, Philadelphia 3, Pennsylvania.
Superior Oil Company, Gas Department, 400 Oil and Gas Building, Houston 2, Texas.
Superior Oil Company, The, 900 Edison Building, Los Angeles 13, California.
Texas Company, The, Box 2332, Houston, Texas.
Texas Company, The, 929 South Broadway, Los Angeles 15, California.
Texas, Pacific Coal and Oil Company, Gasoline Plants, Caddo, Texas.
Tide Water Associated Oil Company, 17 Battery Place, New York, New York.
Tide Water Associated Oil Company, 79 New Montgomery Street, San Francisco 20, California.
Tide Water Associated-Seaboard, Box 731, Tulsa, Oklahoma.
Union Oil Company of California, Union Oil Building, Los Angeles 14, California.
United Gas Pipe Line Company, P. O. Box 1407, Shreveport, Louisiana.
Virginian Gasoline and Oil Company, P. O. Box 2633, Charleston 29, West Virginia.
Warren Petroleum Corporation, Liquefied Petroleum Gas Division, P. O. Box 1589, Tulsa 2, Oklahoma.
Wilmington Gasoline Company, Richfield Building, Los Angeles 13, California.
Wilshire Oil Company, Inc., 1206 Maple Avenue, Los Angeles, California.
Standard Oil Company (Indiana), 910 S. Michigan Avenue, Chicago 80, Illinois.
Wasatch Oil Refining Company, McIntyre Building, Salt Lake City, Utah.

★ ★ ★

Named representative



Joe Fuller

Joe Fuller, Fort Worth, Texas, formerly Mid-Continent representative for France Packing Company, has been made Mid-Continent representative of Harper Packing Company, Chester, Pennsylvania, according to J. A. McPeak, vice president and general manager of that concern.

Division manager

Security Engineering Company, Inc., announces the appointment of D. F. "Duke" Bloom as its Craig, Colorado, division manager. "Duke" brings to his new position 16 years of oilfield experience. His past activities in the Gulf Coast, Oklahoma, New Mexico, California, and Rocky Mountains well qualify him for his new duties.

Heads American Chain

American Chain and Cable Company, Inc. of Bridgeport, Connecticut, announces that Wilmot F. Wheeler has been elected president, succeeding the late William T. Morris. Wheeler has been with the company since 1916, was elected a director in 1919, and treasurer in 1920. He has been executive vice president and treasurer since 1936.

Cyrus N. Johns has been elected executive vice president. Johns joined the Page Steel and Wire Company, now a division of American Chain and Cable Company, Inc., in 1913, and was made general manager of that division in 1933. In 1937 he was elected a diretor of the company and in 1940 vice president in charge of operations of all plants.

Stanley Mann has been elected treasurer. He has been a director of the company since 1936 and assistant treasurer since 1943. Mann was treasurer of Standard Chain Company when it was acquired by American Chain and Cable Company, Inc., in 1917.

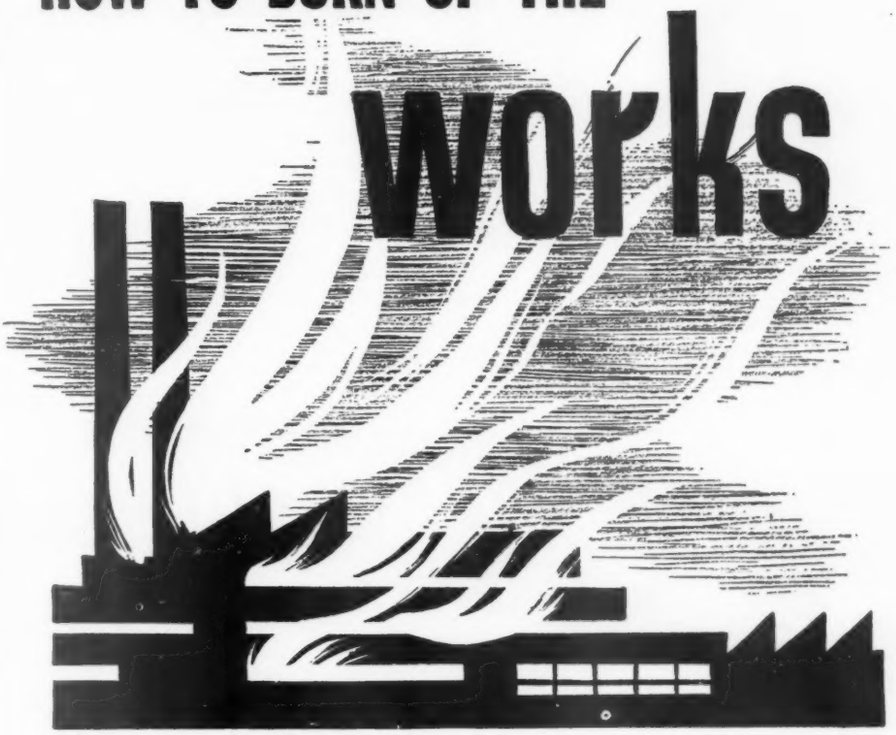
New construction firm

Formation of the Catalytic Engineering and Construction Company to engage in the design and construction of oil refineries and oil refinery equipment is announced by T. Ellwood Webster, of Rosemont, Pennsylvania, president of the new company.

Webster, formerly assistant to the president of Sun Oil Company, said the new company would specialize in the design and construction of catalytic refinery units employing processes licensed by the Houdry Process Corporation, of both the fixed-bed and thermofor moving-bed types.

Alan T. Knight, of Claymont, Delaware, formerly manager of maintenance and construction at Sun Oil Company's

HOW TO BURN UP THE works



THROW WATER ON MOLTEN MAGNESIUM

Burning magnesium metal doused with water may cause a violent conflagration. Other fire extinguishing methods may be equally impotent. *But there is an effective way to control a magnesium fire.* Pyrene G1 Powder has been specially developed and prepared to extinguish fires in burning metals such as magnesium, sodium and potassium. Easily applied with either a shovel or machine.

or USE IMPROPER EXTINGUISHER
ON OIL AND GASOLINE FIRES

Pyrene Foam made at the nozzle of Pyrene Playpipe smothers fire in burning liquids. One man does the job with a hip-pack of air foam and just hydrant or salt water. Fast, safe, certain and most economical.

or THROW WATER ON ELECTRICAL FIRES

Use a Pyrene Vaporizing Liquid extinguisher — a one-quart pump type to a one-gallon pressure type — depending upon size of fire. It's safe because it's a non-conductor.

STANDARDIZE ON PYRENE PROTECTION

Control of fire in all its phases has been Pyrene's business for almost 40 years. There are specific Pyrene Fire Extinguishers for different classes of fires. A Pyrene jobber will be glad to help you determine your fire hazards and advise best methods for protection from them.

Pyrene Manufacturing Company
NEWARK 8 NEW JERSEY
Affiliated with the C-O-Two Fire Equipment Co.

A. T. Knight

T. E. Webster

Marcus Hook (Pa.) Refinery, is vice president of the new company, which was recently incorporated in Delaware. W. Graham Jamison, of Cynwyd, Pennsylvania, is secretary-treasurer, and Vernon L. Stover, of Broomall, Pennsylvania, is assistant secretary. Jamison was formerly chief accountant in the general accounting department in charge of petroleum compensatory adjustments for Sun Oil Company.

Directors of the new company are Webster; Knight; Arthur E. Pew, Jr., vice president of Sun Oil Company in charge of manufacturing and research; Clarence H. Thayer, chief engineer and a director of Sun Oil Company; Robert G. Dunlop, comptroller and a director of Sun Oil Company.

Headquarters of the new company will be at 1608 Walnut Street, Philadelphia.

Consolidate departments

In a move designed to give greater emphasis to mechanical development and engineering research, Standard Oil Development Company, central technical organization of Standard Oil Company (New Jersey), has announced consolidation of its engineering departments.

The consolidation brings into one organization more than 400 scientists and other employes of the General Engineering Department and the Process Engineering Department, which have operated independently for nearly 10 years. The new organization, named the Esso Engineering Department, is directed by E. W. Luster, chief engineer, who reports to Dr. N. E. Loomis, vice president in charge of engineering.

The regrouping, Dr. Loomis said, is

E. W. Luster

E. H. Barlow

expected to place greater attention on mechanical engineering and engineering research work, improve work supervision, and increase efficiency. The department's activities also will be expanded to cover not only refining, but certain engineering problems in other lines of Jersey's activities.

Under the new setup, E. H. Barlow, former chief engineer, becomes consulting engineer of the development company, handling many of the contacts with company executives on engineering matters of general interest. Assistants to Luster are P. J. Byrne of the Process Engineering Department; C. E. Paules of the General Engineering Department, and N. F. Myers, former associate manager of the process division.

C. T. Harding is named chief process engineer, C. F. Hesselbach, chief mechanical engineer, and A. J. Ely, chief construction engineer. As part of the reorganization, a group of project engineers including G. W. Bauer, E. H. Clendenin, P. J. Harrington, C. A. Hillman, E. H. Kares, and J. R. Schonberg, will serve as coordinators.

Director of engineering

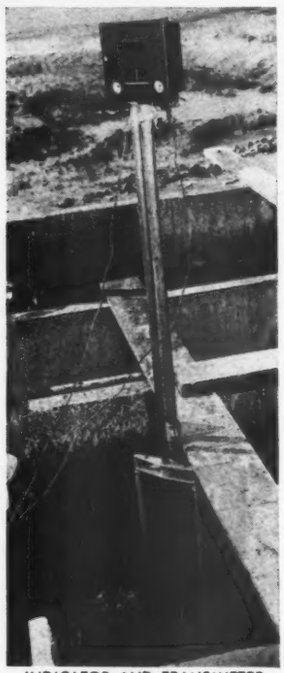
The appointment of L. B. Gordon to the new position of director of engineering of the Dayton Rubber Manufacturing Company has been announced. This groups all plant, electrical, power, and efficiency engineering as well as machine design and plant layout in one division.

Gordon takes his new position with a broad background in electrical and mechanical engineering and production, having held the position of director of engineering with one of the major rubber companies for more than 20 years.

BLOWOUT PREVENTION

BY PIT LEVEL OBSERVATION

Pit-O-Graf



INDICATOR AND TRANSMITTER

RECORDING UNIT

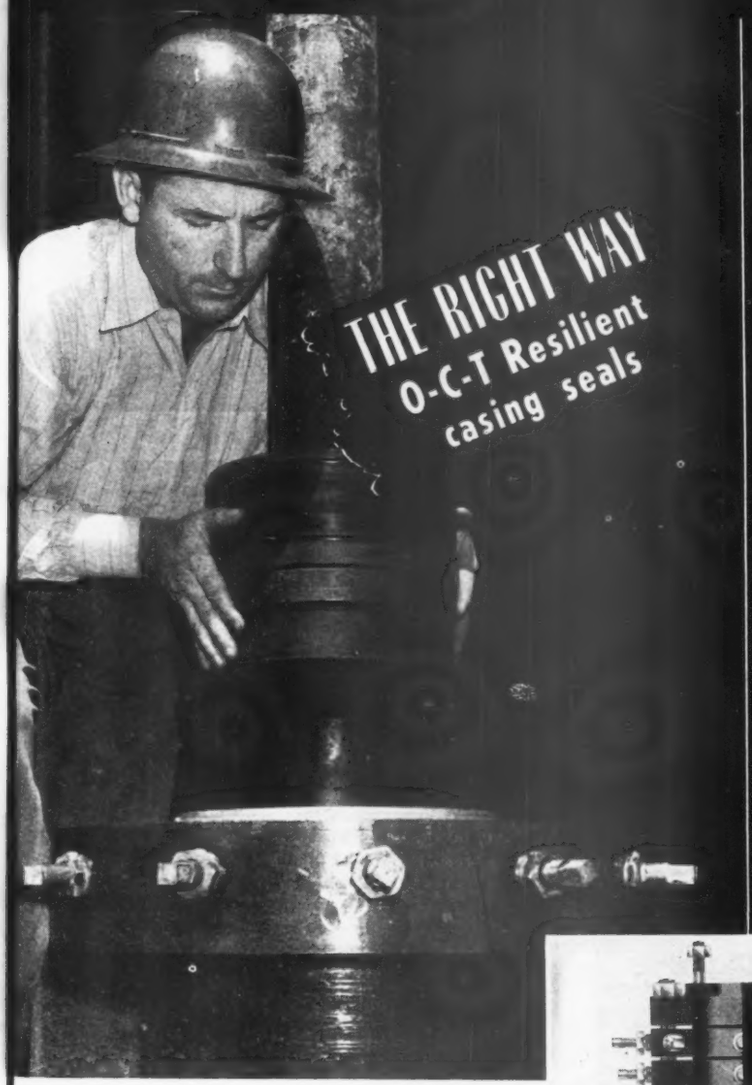
Experienced drillers and operators are well aware of the danger signaled by variations of fluid level in the pit. The Pit-O-Graf continuously and automatically transmits mud pit level variations to a chart on the derrick floor, in constant view of the driller. This accurate and instant recording of mud pit level fluctuations is warning of a potential blowout in ample time to take steps for its prevention. There can be no doubt as to whether or not the volume of mud in the suction pit is increasing or decreasing when the Pit-O-Graf is used.

The Pit-O-Graf transmitter unit is mounted in the mud pit with a perfectly balanced float resting on the fluid. The slightest rise or fall of the float is immediately transmitted to the recorder, and shown in tenths of a foot on a 24-hour chart. Intensive research and more than a year's exhaustive field tests have demonstrated the value and importance of the Pit-O-Graf. Write for new bulletin of detailed information.

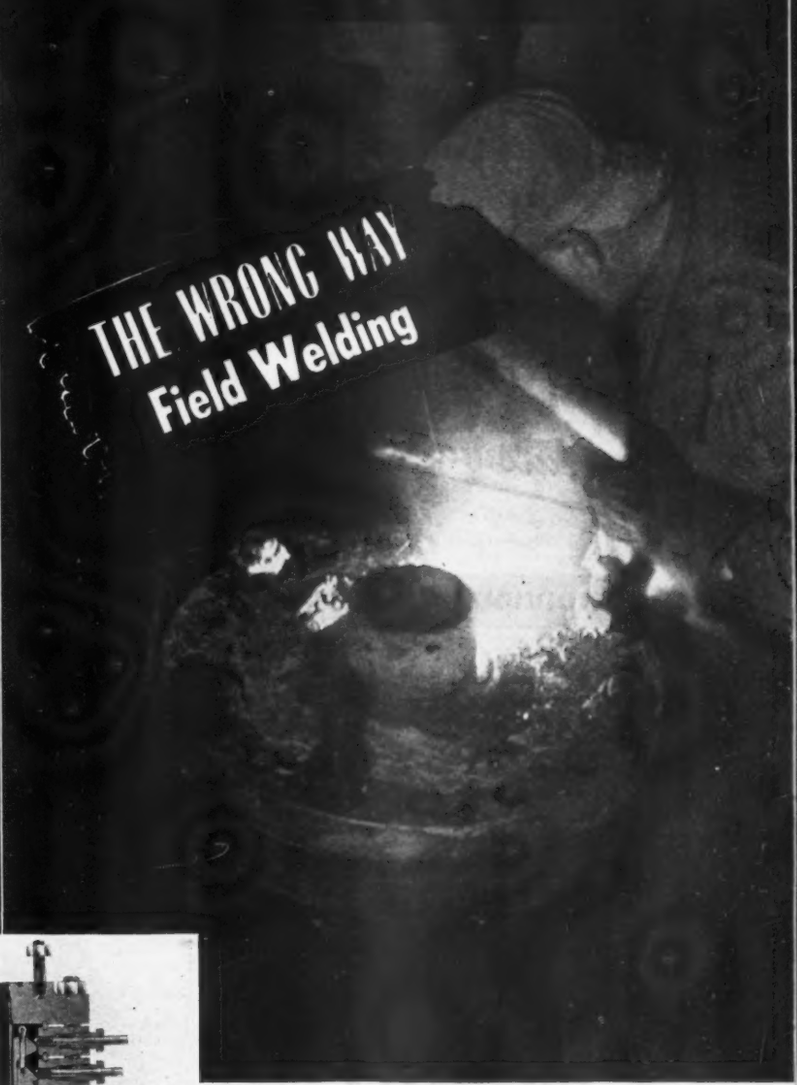
WARREN AUTOMATIC TOOL CO.

1920 HUSSION STREET HOUSTON 3, TEXAS

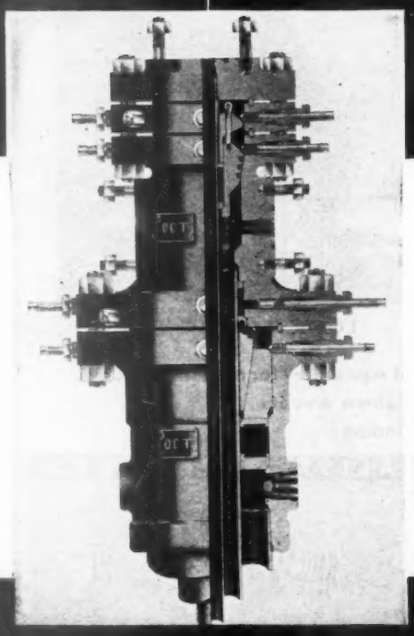
WARREN AUTOMATIC TOOL CO HOUSTON WATCO



THE RIGHT WAY
O-C-T Resilient
casing seals



THE WRONG WAY
Field Welding



O-C-T engineers have long shared the opinion with numerous operators that welded casing seals are both impractical and hazardous. Impractical because of the difficulties involved in obtaining a reliable welder when needed, transporting welding equipment to remote locations, loss of rig time, etc. Hazardous because of the lack of a means for stress-relieving after welding and, consequently obtaining a welded seal of questionable efficiency.

On the other hand, many operators have used O-C-T well heads employing resilient seal rings with complete satisfaction. Note in the cross-section drawing presented herewith how lock-down screws provided in the casing head flange and the lower flange of the tubing head permit the application of compression on the resilient seal rings, which are made from a special heat, oil and gas resistant synthetic (Hycar) rubber. The fact that such well heads are performing satisfactorily in most of the deep, high-pressure fields throughout the Gulf Coast should provide sufficient proof of their ability to effect and maintain a pressure-tight seal indefinitely.

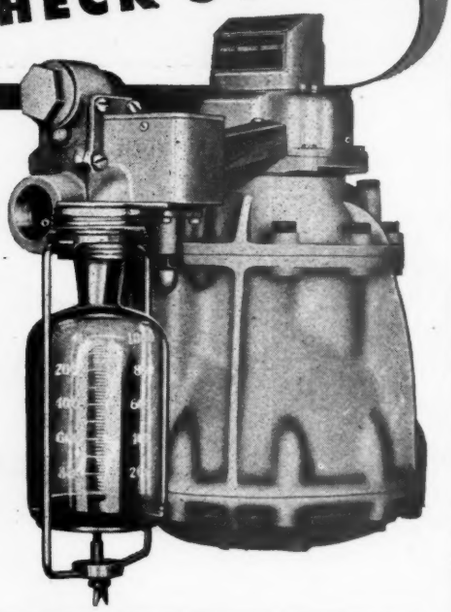
Write or wire for full particulars.

HOUSTON, TEXAS — EXPORT: VAL R. WITTICH, 30 ROCKEFELLER PLAZA, NEW YORK, N. Y.

BOWSER
ESTABLISHED 1885

WELL-CHECK SYSTEM

SAMPLES
and
METERS
CRUDE PRODUCTION
AT THE WELL
Automatically



INDIVIDUAL WELL PRODUCTION RECORDS MEAN...

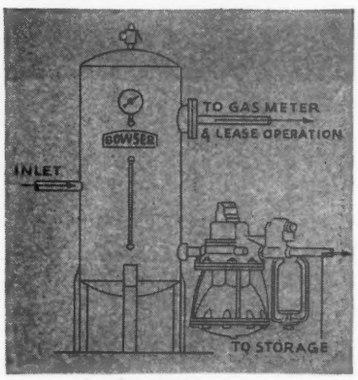
- Accurate and indisputable basis for royalty and tax payments.
- Elimination of gauge tanks, piping and handling.
- G/O ratios for conservation and reservoir study.
- Prevention of evaporation losses due to weathering.
- Quick detection of sleepers or wet wells.
- Lower transportation costs by utilization of well energy.
- Reduced fire and other hazards.
- True proportionate samples of each well's production.

QUALITY

with true proportionate sample provided by Bowser Automatic Well Sampler.

QUANTITY

with Bowser Special Oil Field Meter. Dependable operation—no metal-to-metal contact.



LOOK FOR BOWSER

Write today for the new Bowser booklet of equipment for modern oil fields.
Bowser, Inc., 1329 Creighton Avenue,
Fort Wayne 2, Indiana

LIQUID CONTROL SPECIALISTS SINCE 1885

J & L changes

The establishment of a new district sales office in Indianapolis and changes involving its district sales offices in Los Angeles and San Francisco, and South Bend, Indiana, have been announced by the Jones and Laughlin Steel Corporation.

H. M. Knobloch has been appointed district sales manager in Indianapolis. Since October 1944 he has been assistant district sales manager in Cincinnati.

R. G. Scoggins has been appointed district sales manager in Los Angeles. He succeeds T. W. Bell who has been

W. L. O'Connell

W. S. Wainwright

R. G. Scoggins

H. M. Knobloch

appointed special sales representative in Los Angeles. Since January, 1945, Scoggins has been associated with the J & L district sales office in Memphis.

W. S. Wainwright has been appointed district sales manager in San Francisco. Wainwright has been associated with J & L since 1936, having started in the Pittsburgh sales office. For the last 5 years he has been a salesman in the wire sales department in Pittsburgh.

W. L. O'Connell has been appointed resident manager of sales in South Bend. O'Connell has been resident manager of sales in Indianapolis since 1942.

Walter Miller retires

A man who rose from blacksmith's helper to become vice president of a major oil company and one of the outstanding figures in the petroleum industry has retired. He is Dr. Walter Miller, whose retirement as vice president in charge of manufacturing, Continental Oil Company, was announced by Dan Moran, Continental president.

Dr. Miller came to the United States from Switzerland when he was a small boy and lived in New York City and then in Elizabeth, New Jersey. There he completed his elementary school education.

For several years after his graduation he held various positions among which

were blacksmith's helper, machinist's helper, bookkeeper, and responsible assignments with an art picture reproducing company.

In 1909 he went to the Bayonne, New Jersey, refinery of Tide Water Oil Company as field clerk. His spare hours were spent in attending night school. His interests were chemistry, accounting, and engineering.

At Bayonne he reached the rank of process superintendent and then resigned to join Pierce Refining Company, Tulsa, as general superintendent of three refineries. Six months later he was made refinery manager of Cosden and Company, now the Mid-Continent Petroleum Corporation.

During the latter part of 1921, his time was occupied with consulting refining work for Marland Oil Company, and in 1922 he took full charge of Marland refining operations. When Marland and Continental oil companies merged in 1929, Dr. Miller continued as vice president in charge of manufacturing.

Dr. Miller will continue active work in the oil industry by devoting his time to a consulting service for clients seeking assistance in refinery processing.

Harold G. Osborn, manager of manufacturing, will assume full charge of Continental Oil Company's 8 refineries, Moran announced.

Ballagh president

J. C. Ballagh

Patterson - Ballagh Corporation announces the appointment of J. C. Ballagh as president. Jack Ballagh is well known throughout the oil world as a pioneer of the rubber drill pipe and casing protector, and also for his active development of many rubber oil field specialties during the last 18 years.

Although he now has been officially elected to the president's chair, he will continue in charge of sales promotion and development, which he has directed since the company's inception in 1927.

ASSEMBLING REQUIRES NO SPECIAL FITTING

• Assembling is greatly simplified by Lunkenheimer precision production . . . parts are so accurately made that special fitting isn't necessary.

LUNKENHEIMER

Precision Workmanship

SUPER ACCURACY IN EVERY PART

...LONGER SERVICE LIFE

Fig. 2125 Bronze Double Disc Gate

Fig. 1430 Iron Body. Gate

• You can't fool the maintenance men on valve quality. They know that when a valve has a much longer than average service life, that valve has superior accuracy and precision built into it from handwheel to pipe threads.

Such valves are the only kind that Lunkenheimer has ever produced. For over three quarters of a century, the Lunkenheimer quality ideal has won ever widening acceptance until today it is a recognized tradition in American industry.

Lunkenheimer quality is the balanced combination of many factors. Among them are finest raw materials approved by constant testing and research . . . sound, advanced design . . . highly skilled workmanship . . . absolute accuracy . . . perfect alignment of all parts.

As an inevitable result — wherever you find Lunkenheimer Valves you find maintenance cost records consistently lower.

Your LUNKENHEIMER Distributor

— is an important link in the nationwide Lunkenheimer chain of better, more efficient, more reliable valve service. He is fully equipped to assist in the solution of valve maintenance and operating problems. In addition, he can make prompt arrangements to have a Lunkenheimer Engineer call at the plant whenever technical valve engineering knowledge is required.

THE LUNKENHEIMER CO., Cincinnati 14, Ohio, U.S.A.

Offices: New York 13, Chicago 6, Boston 10, Philadelphia 7.

Export Department: 319-322 Hudson St., New York 13, N. Y.

Lufkin engineers meet

The sales and service engineers of the Lufkin Foundry and Machine Company met for their annual sales meeting at the head office in Lufkin, Texas, February 23. Sales plans were made for the ensuing year and the new equipment offered by this company was discussed.

Although Lufkin company produced a tremendous quantity of goods for the prosecution of the war, it maintained quite a research staff for the purpose of developing new equipment, making improvements on its regular line of reduction gears, oil well units, etc. This company is now building a complete line of commercial reduction gears, speed increasers, oil field pumping engines, and truck trailers of the oil field and van type, in addition to commercial grey iron castings.

First row, left to right: D. A. Reid, E. H. Bounds, L. A. Little, M. B. Harrison, C. D. Richards. Second row, left to right: R. L. Miller, A. E. Cudlipp, L. A. Long, A. E. Caraway, W. T. Crowder, J. B. Hopper. Third row, left to right: Gus Winn, Robert Lang, J. Taylor Hood, W. H. Miner, Elvin Reed. Fourth row, left to right: V. B. Glenn, W. C. Trout, W. W. Trout, H. A. McKerrall, E. P. Trout, G. L. Vickrey, D. K. Womack.

Lufkin also operates a wholesale jobbing business, specializing in industrial and automotives supplies, equipment, and parts.

Elected vice president

W. B. Woody, for 9 years chief engineer of Franks Manufacturing Corporation of Tulsa, has been elected vice president in charge of engineering, Carl White, Jr., Franks president announces.

Joining the Franks organization in December, 1936, Woody immediately assumed charge of the engineering department, then in its initial development. Gradually under his direction, the engineering group was enlarged and continued growing until in 1940, the staff numbered 10 employes. The present group that Woody heads consists of 18 full-time employes.

W. B. Woody

In his 9 years' association with the Franks corporation, Woody has had a hand in a number of the outstanding developments in oil field equipment.

"Woody's promotion is not away from the engineering problems he has so closely supervised at Franks, but will enable him to spend more time in designing and engineering for the future. It will be his province to keep Franks products new and improved," said White.

A.C.S. chairman

E. G. Hammerschmidt, chief chemist of the Texoma Natural Gas Company, Fritch, Texas, has been elected chairman of the Panhandle Plains Section of the American Chemical Society, succeeding Emmett B. Reinbold of the J. M. Huber Corporation, Borger, Texas.

Other new section officers are: Dr. R. G. Atkinson of the Shamrock Oil and Gas Company, Amarillo, Texas, chairman-elect; E. M. Frost, Jr., of the U. S. Bureau of Mines, Cryogenic Laboratories, Amarillo, secretary, and Miss Bertie Warren, Amarillo College, treasurer.

AMERICAN RADIAL ROLLER BEARINGS are *precision built* for almost every heavy-duty bearing application where the load is radial. Use of AMERICANS in heavy machinery lowers maintenance costs and increases the performance-life of vital equipment. AMERICAN RADIAL ROLLER BEARINGS are readily adaptable because the outer race is removable for easy assembly. Rugged durability and long life are assured by special heat-treated alloy steel. Constant inspection and precision tests make for absolute accuracy and smooth, quiet performance. AMERICAN RADIAL ROLLER BEARINGS are made in five styles, 4 S.A.E. series and 85 sizes. Special designs to your requirements are also available. Write today.

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Pacific Coast Office: 1718 S. Flower St., Los Angeles, Calif.

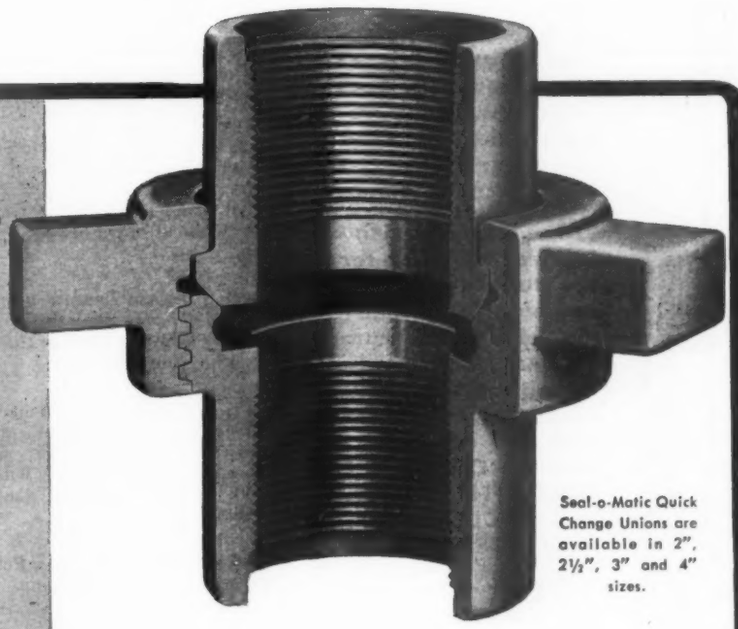
AMERICAN

Heavy-Duty ROLLER BEARINGS

...GUIBERSON'S SEAL-o-MATIC Quick Change Union is back again

SEAL-o-MATIC Quick Change Union will stand up to the toughest working conditions... a low cost investment which pays dividends by saving costly replacements and man hours in the field and assures a quick, dependable coupling for mud, cement, and acidizing lines, as well as for high pressure oil, gas, or water lines... ideal for Christmas Trees.

Guiberson's SEAL-O-MATIC Quick Change Union harnesses pressure within the line and puts it to work by the self-sealing action of the SEAL-O-MATIC Ring. This flexible ring of oil and acid resistant compound seals from line pressures, independent of the tightness of the wing-nut... and it seals either high or low pressures... makes up by hand. Field replacement of ring is easily accomplished.



Seal-o-Matic Quick Change Unions are available in 2", 2½", 3" and 4" sizes.

FLEXIBLE LIPS UTILIZE PRESSURE TO EFFECT A SEAL

RIB HOLDS SEAL-O-MATIC RING IN PLACE WHEN UNION IS DISCONNECTED

SAFE THAN SORRY GUIBERSON BETTER BE

Reg. U. S. Pat. Off.

Manufacturers of oil field equipment, steel cabinets, domestic oil heaters, sheet metal products, and molded rubber products.

Guiberson U.S.A.

THE GUIBERSON CORPORATION

Dallas, Texas — Established 1919

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Export representative: I. Frank Brown, 30 Rockefeller Plaza, New York, N. Y.

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IT'S MODERN

MID-CO

CLEAN-OUT
BAILER

The thousands of Mid-co Bailers in use throughout the World—The accomplishments of the operators using this Oil Well Clean-Out Tool—The inevitable repeat orders prove its superiority in Oil Well reconditioning.

The job to be done is never too tough for the sturdily built Mid-co Clean-Out Bailer—Manufactured from the best materials obtainable—Accurately machined and fitted with but one objective—TO CREATE THE MOST EFFICIENT OIL WELL CLEAN-OUT TOOL POSSIBLE.

G-Type is recommended when cleaning out or drilling by anything in the hole such as tubing, tools, etc.

FOR ADDITIONAL INFORMATION SEE
COMPOSITE CATALOG
PAGE 1903

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TELEPHONE 7-8586 BOX 1542
OKLAHOMA CITY · OKLAHOMA

LAUGH WITH BARNEY

"Thirty years ago," said the man who had traveled to the end of the earth and most of the way back, "I started out, alone, unaided, without friends to help me along, with the intention of making the world pay me the living it owes me. My only allies were a dollar bill and a determination to make a million more... "Today," and he threw out his chest proudly, "I still have that determination... and fifty cents in change."

* * *

Young Man: Father, I've a notion to settle down and start raising chickens.
Father: Better try owls. The hours will suit you better.

* * *

They were training Mandy in her duties as maid. Upon answering the phone the first day, she brought no message, but explained: "Twarn't nobody, 'jes a man says: 'It's a long distance from New York'; and I says, 'Yes sir, it certainly is'."

* * *

We're beginning to wonder whether our friends drop in for a wee visit, or visit for a wee drop.

* * *

Thirty is a nice age for a woman, especially if she happens to be forty.

* * *

"Give me your name and address," barked the clerk to the dusky draftee.
"What zat?"
"What's your name and address?"
"Seems lak yo' ought to know—yo' all sent for me."

* * *

Captain: Seaman Jones, it gives me great pleasure to give you these two stripes.
Seaman: Why not give me three, sir, and really enjoy yourself?

* * *

A sales manager summoned one of his men to his office and asked: "What's this big item on your expense account?"
The salesman replied: "My hotel bill."
"Well," advised the s.m., "don't buy any more hotels."

* * *

We suppose you heard that a Peeping Tom is only a wolf window shopping.

* * *

This gag made the rounds as the riddled Seventh Marines made their advancement on Jap cave strongholds in the sweltering jungle battlefields. It was passed from man to man, shouted from behind boulders, whispered into ears in the underbrush:
"Gonna be tough sleddin' today."
"How come?"
"No snow!"

* * *

Letter from an irate citizen living close to the railroad yards:
"Gentlemen: Why is it that your switch engine has to ding and dong and fizz and spit and bump and chug and hiss and pant and grate and grind and hoot and toot and whistle and wheeze and jar and jerk and howl and snarl and puff and groan and thump and boom and smash and jolt and screech and snort and slam and throb and roar and rattle and yell and smoke and shriek like hell all night long?"

* * *

Marriage is like a tub full of hot water... after a while it's not so hot.

"What are you putting in your vest pocket there, Murphy?"
"That's a stick of dynamite. Every time that Riley sees me he slaps me on the chest and breaks all of my cigars. The next time he does it, he's going to blow his hand off."

* * *

Two mind readers meet on the street: "You're fine, how am I?"

* * *

Removing his shoes, he climbed the stairs, opened the door of the room, entered and closed the door without being detected.
But just as he was about to get into bed, his wife, half-aroused from her slumbers, murmured, "Is that you, Fido?"
And for once in his life the husband had real presence of mind. He licked her hand and she went back to sleep.

* * *

There are few of the great philosophers who have made a greater contribution to the science of happiness than the hard-working Negro woman who had a thoroughly lazy but likable husband. When she was asked why she put up with him, she answered:
"Well, it's this way; I makes the livin', and he makes the livin' worth while."

* * *

This was way back in the 'sixties when the first train was crossing the plains of Texas. Charging down the track headed straight for the locomotive, the engineer saw a shaggy monster of a buffalo coming full tilt. And the man at the throttle observed:
"Old boy, I sure admire your nerve; but damn your judgment."

* * *

Two farmers went fishing one day, and when they got home, they compared their experiences. One said he had caught a 200 pound salmon. The other called his attention to the fact that salmon never weigh 200 pounds, but the first stuck to what he claimed. Then he asked:
"What did *you* catch?"
"Well," was the reply, "all I got was a rusty old lantern bearing the inscription 'Captain Kidd, 1756', and, would you believe it, there was a lighted candle inside it."
The first fisherman gulped, cleared his throat, and said:
"Looka here. Let's get together on our fish stories. I'll take 100 pounds off my salmon if you'll put out the candle in that there lantern."

* * *

The touring company gave a performance of "King Lear," and the local critic wrote: "If Shakespeare could have seen his play performed he would have turned in his grave."
Next night the same company did "Othello," and the leading actor thought he had made a hit this time, until he opened his paper and read: "We thank the company at the Buskin Theatre. Shakespeare is now on his back again."

* * *

It was pouring. Two men who had quarreled went out in the rain to settle their differences. They fought until one got the other on his back and held him there.
"Will you give up?" he asked, and the reply was "No."
After a time the question was repeated, but again the reply was "No."
"Then," said the other, "will you get on top for a while and let me get under? I'm getting soaked."

BAKER *Triplex* CEMENTING SHOE

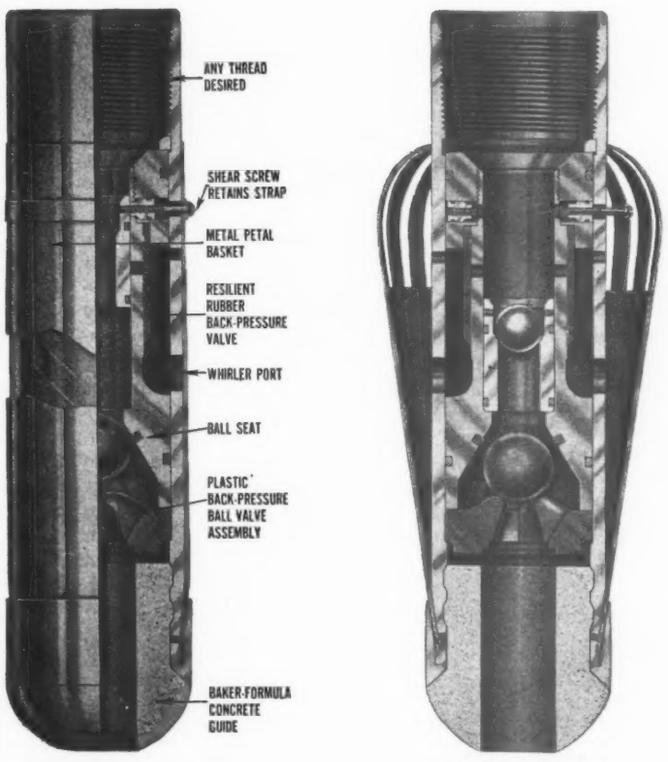
Packs Off in Large Diameter, or Irregularly-Shaped Holes, and Retains Cement Slurry Above the Shoe

WHAT IT WILL DO. The Baker TRIPLEX Cementing Shoe basically is a casing shoe and operates as a conventional float shoe while running-in, washing and conditioning the hole. Its principal use is to retain all cement slurry above the shoe, thus protecting formations below from cement contamination.

All cement slurry is directed upward through side whirler ports; a sleeve-type, back-pressure valve prevents any return flow of slurry. The Baker Metal Petal Basket is intended to form a bridge, thus preventing cement slurry from settling into permeable, low-pressure zones below. The Basket is indispensable in large-diameter, or irregular-shaped holes.

FAST, SAFE OPERATION. The Baker TRIPLEX Cementing Shoe is secured to the lower end of the casing and provides the advantages of all Baker FLOATING Equipment in safely guiding, floating and landing strings of casing of any size or length. The rounded nose of Baker-Formula Concrete guides the casing past any side-wall irregularities. The Baker PLASTIC Valve Assembly—with the buoyant Plastic ball that floats in cement slurry—maintains a constant, leakproof seal against either high or low pressure.

Then, after reaching the desired point in the hole, circulation is established through the ample interior passageways of the shoe, and the hole is conditioned preparatory to cementing. The Tripping Ball now is pumped (or allowed to gravitate) down the hole to seat upon the Tripping Valve. A pressure of 400 to 500 psi is applied to the casing which shears the screws in the Tripping Valve, permitting it to move downward and expose the cementing ports. Shearing the screws also releases the hold-down strap around the basket, allowing the basket to expand outwardly against the wall of the hole. The cementing operation is then carried out in the conventional manner with all cement slurry directed upward and held above the shoe by the expanded Baker Metal Petal Basket.



RUNNING-IN POSITION EXPANDED POSITION

STRONG, SIMPLE CONSTRUCTION. The Baker TRIPLEX Cementing Shoe consists of a whirler float shoe with a Baker Metal Petal Basket fastened on the shoe below the cementing ports. All cement slurry is directed upward and retained above the shoe. A fabric reinforced, resilient rubber, sleeve-type back-pressure valve opens readily to permit passage of the slurry into the annulus above the shoe, but closes instantly to prevent any return flow of slurry.

All internal parts are made of readily drillable materials. Two one-half inch set screws hold the inner assembly stationary to facilitate drilling out the shoe.

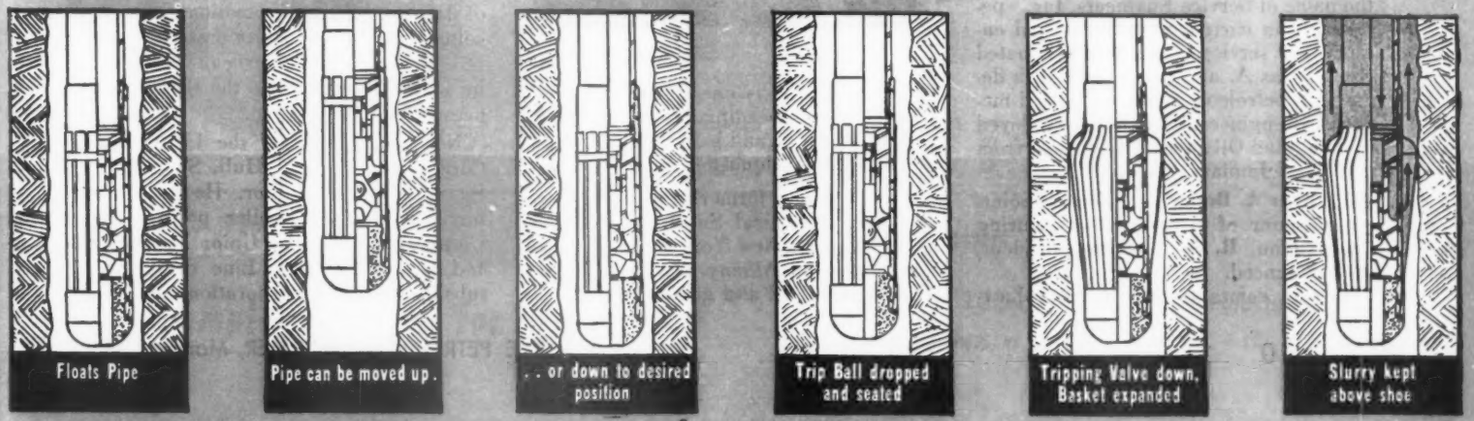
EASY TO ORDER AND USE. When ordering the Baker TRIPLEX Cementing Shoe it is necessary to give only the size, weight and thread specifications of the casing upon which it is to be run. It is advisable to furnish hole size, because (a) the TRIPLEX Shoe is approximately ½" larger than the O.D. of a standard casing coupling; and (b) the Metal Petal Basket must be of sufficient size to expand and pack-off even in large-diameter and irregularly-shaped holes.

The use of a Baker TRIPLEX Cementing Shoe is no problem to experienced cementers. Its effectiveness is evident from the demand from all active fields. Contact your nearest Baker office or representative.

BAKER OIL TOOLS, INC.

Houston — Tulsa — Los Angeles — New York

"There's a Baker Man in Your Territory"


Floats Pipe
Pipe can be moved up.
. . or down to desired position
Trip Ball dropped and seated
Tripping Valve down, Basket expanded
Slurry kept above shoe

Running Tour WITH MEN IN THE INDUSTRY

● **Lt. Col. Hugh A. Neal** rejoins Phillips Petroleum Company, Bartlesville, Oklahoma, as assistant manager, Perco division, chemical products department after 5 years in the parachute field artillery, U. S. Army. Neal commanded the artillery of the Army's first parachute combat team going into Sicily. Subsequently, he saw continuous action in Italy until wounded on May 31, 1944. After hospitalization he was assigned to Ft. Sill, Okla., until released, thus completing one of the longest military leaves in the Phillips organization.

Lt. Col. Hugh A. Neal

● **G. A. Holloway** has been transferred from Wichita, Kansas, to Dallas, Texas, it has been announced by C. R. Krause, president of Lee C. Moore and Company, Inc. Holloway becomes district manager for the company, with headquarters at Dallas.

● **L. T. Daniel,** formerly division petroleum engineer at Shreveport for Magnolia, has been promoted to district superintendent at Kermit, replacing **Ed. L. Downing,** who has been transferred to district superintendent at Houston. **J. B. Goodrich,** formerly district superintendent at Lake Charles, has been promoted to Houston as gulf coast division superintendent replacing **M. V. C. Bradley,** who has been promoted to assistant general superintendent at Dallas. **W. B. Powers,** formerly assistant district superintendent, has been advanced to acting superintendent at Lake Charles. **M. M. Keeble** has been promoted to superintendent at Shreveport replacing **H. B. Lamb,** who has retired.

● **D. R. Ford** has been promoted to superintendent of the southern division of Magnolia Pipe Line Company at Houston, replacing **J. E. McGath,** who has been advanced to assistant general superintendent at Dallas. **C. C. Coffindaffer** has been promoted to district superintendent of Olden.

● **J. A. Clay, Jr.,** has opened offices in the First National Bank Building in Fort Worth as a consulting engineer under the name of Service Engineers, Inc., specializing in corrosion and electrical engineering service. Clay was graduated from Texas A. and M. in 1941 with degrees in petroleum engineering and mechanical engineering. He was employed by Stanolind Oil and Gas Company from then until January of this year.

● **Walter A. Bowers** has been appointed treasurer of Aireon Manufacturing Corporation, **R. C. Walker,** president, has announced.

Bowers comes to Aireon from Lawrance Aeronautical Corporation of Linden, New Jersey, where he was vice president and treasurer. Prior to joining Lawrance in 1944 he was 15 years in executive and administrative positions in government service.

● **Rudyard C. McKee** has joined Needham, Louis and Brorby, Inc., Chicago, as an account executive. McKee was formerly assistant advertising manager of Standard Oil Company (Indiana).

● **Tom Lawrence Turner,** recently resigned as manager of the American Iron and Machine Works Company, Houston branch, has established offices in Houston to serve the Mid-Continent oil area as a manufacturers' agent. His offices are at 531-532 Neils Esperson Building, Houston 2, Texas.

● **Huston W. Bartholomew,** superintendent of the Cooper-Bessemer Corporation's Grove City, Pennsylvania, plant, died January 24 of cerebral hemorrhage. Bartholomew, who had been associated with Cooper-Bessemer 44 years, was well known in the diesel, gas engine, and compressor field.

● **Richard H. Wherry** has been appointed chief engineer of the Liquefied Petroleum Gas Division, The Weatherhead Company, Cleveland, Ohio. Formerly assistant to the chief engineer of the Liquefied Petroleum Gas Division of the Skelly Oil Company, Wherry was also a member of the technical and standards committee of the Liquefied Petroleum Gas Association, and a member of the technical and standards subcommittee in charge of suggested revision of Underwriters Pamphlet No. 58, the generally accepted bible of the liquefied petroleum gas industry.

● **Andrew L. Weigand** and **Dave C. Neely** have returned from a four months' tour of South American oilfields in the interests of Spang-Chalfant tubular products. Neely is one of Spang's field engineers with headquarters in Houston, Texas, and Weigand is foreign representative with headquarters in New York.

D. C. Neely A. L. Weigand

● **E. T. Heck,** formerly with the West Virginia Geological Survey, has joined the staff of the New York State Geological Survey at Albany. He is to be in charge of all oil and gas investigations.

● **Arch F. Campbell,** manager of the petroleum industry sales office of General Motors Detroit Diesel Engine Division, has announced the appointment of **King D. Boyd** as district manager of petroleum industry sales in the Gulf Coast region. Boyd, a mechanical engineering graduate of the University of Oklahoma, will be in Houston, Texas. Prior to the war, Boyd was associated with the University of Oklahoma as an instructor in engineering; the Reed Roller Bit Company; the U. S. Government in Washington, D. C. and in the Panama Canal Zone as a mechanical engineer, and with the Emerson Electric Company. He has spent the last three years with the Navy as a Lieutenant (sg).

King D. Boyd

● **J. H. Graham** has been appointed Continental Oil Company's assistant manager, production and drilling department east of the Rocky mountains. He will maintain headquarters at Houston.

● **Arthur E. DesNoyers** has been named director of procurement for Aireon Manufacturing Corporation. **Russell J. Cole,** who has been responsible for the terrific load of postwar procurement, will continue as chief purchasing agent. DesNoyers, a major in the air forces and attached to General Arnold's staff, worked on the procurement, planning and control of radar and radio equipment peculiar to the Army Air Forces. **Daniel Wolfred** has been appointed works manager for the Aireon Manufacturing Corporation. Wolfred brings considerable production experience to his new position having joined Aireon's hydraulics division at Burbank, California, in March, 1944. He was transferred to the electronics division in Kansas City last September.

● **L. V. Tracht,** of Houston, formerly assistant treasurer of United Gas Corporation and its subsidiaries has been elected as treasurer of the corporation. He will be succeeded by **A. J. Biard,** also of Houston. These promotions have resulted from the vacancies created by the recent death of **S. L. Davis** and the transfer of **J. C. Flanagan** to the Houston offices of the corporation.

New comptroller of the United Gas Corporation is **R. E. Hull,** Shreveport, former general auditor. He will also serve in the comptroller position for United Gas Pipe Line, Union Producing and United Oil Pipe Line companies, subsidiaries of the corporation. Succeed-

Tret-O-lite pays

Extra

dividends

Even though your crude already meets the standard water allowance for pipe line acceptance, you may not be getting the most out of it. Often by treating the same crude with a little more of the same Tret-O-lite formula you can obtain oil with a lower water content and consequently a higher gravity. Thus a small additional investment in Tret-O-lite may bring you a premium price for your oil. Our field engineers are trained to recognize such conditions —a survey by the Tretolite field man in your territory may uncover hidden profits for you—it's certainly worth a phone call to find out.

46-C

Complete Service for Every Field

Tret-O-lite

REG. U. S. PAT. OFF.

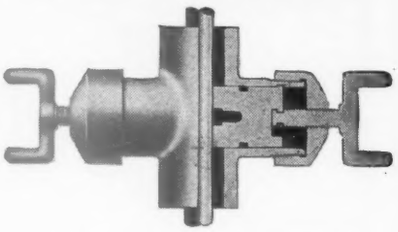
DEHYDRATING **DESALTING**

TRETOLITE COMPANY *Manufacturing Chemists*

WEBSTER GROVES, ST. LOUIS COUNTY, MO. • LOS ANGELES, CALIF.

Say "DOUBLE E"
WHEN YOU WANT .... The Best

BLOW OUT PREVENTER



The "Double E" Blowout Preventer for sucker or polished rods works on the same principle as the stripper but is constructed somewhat differently. Instead of the soft rubber packing, cylindrical steel rams are used, to which has been molded a fabric reinforced sealing element. This oil resistant synthetic rubber element backed by the steel ram prevents leakage against high pressure.

The use of the Blowout Preventer in conjunction with the Sucker Rod Stripper provides ideal protection against handling wet rods and pressure surges in heading wells.

"DOUBLE E" Products
EQUIPMENT ENGINEERS
INCORPORATED
2039 AMELIA STREET
DALLAS 9, TEXAS

ing Hull as general auditor is **F. E. Waltrip,** Shreveport, who was assistant to Hull for several years. Like his predecessor, he will act as auditor for the corporation and its three associated companies. **J. H. Miracle,** Shreveport man who has served as secretary of the subsidiary producing and transmission companies, was elected secretary of the corporation, retaining his former multiple job as well. Four other Shreveport men were advanced to higher positions in United Gas Pipe Line Company. They are **M. V. Cousins,** new director of personnel; **D. R. Pflug,** assistant chief engineer; **H. W. Egger,** superintendent of compressor stations; and **H. W. Eiser,** superintendent of transportation for all three subsidiary companies.

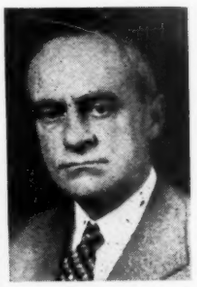
● **Thad Randolph** and **Jack Long,** both discharged from the Navy, are now associated with Oil Base, Incorporated, and will be stationed in the Mid-Continent area with headquarters in Tulsa, Oklahoma, some time around March 1st.

● **E. F. Battson,** New York City, has been appointed assistant to the president, Continental Oil Company. He succeeds **George D. Olds,** who has resigned. In taking over Olds' position, Battson also assumes chairmanship of the advertising committee and of the manufacturing and sales committee. He joined Continental as a marketing district superintendent at Richfield, Utah, in 1922. He received several promotions, being made assistant division manager, Butte, Montana, in 1925; division manager there in 1929; assistant general sales manager, Kansas City; eastern sales manager, New York City; northern sales manager, Chicago, and returned to New York in 1942. He took over supervision of government contracts and sales, and export sales, in 1944, and will continue to handle this work. **F. B. Haverfield** has been appointed manager of the natural gasoline and gas division of Continental. He succeeds **R. A. Carter,** who resigned. Haverfield became associated with Continental in 1929, when he joined the company as plant chemist, Big Lake field, Texas. Following several promotions at Continental's Basile, Louisiana, plant, he was made assistant superintendent of the gasoline department, with headquarters at Ponca City, in 1939 and was appointed assistant manager 4 years later. He will be succeeded by **D. B. Edwards,** assistant to manager of the department since 1943. **F. B. Willson,** assistant process engineer, succeeds Edwards as assistant to manager.

F. B. Haverfield

The promotion of **C. R. Allen** to proration engineer, production and drilling department has also been announced by Continental. He succeeds **R. Van A. Mills,** who retires under the company's retirement annuity benefit plan.

● **Arthur H. Sherwood** has been appointed eastern sales manager of Petro-Chem Development Company of New York City, designers, fabricators, and erectors of furnaces for the petro-chemical industries. Sherwood, who is well known throughout the petroleum and chemical industries, comes to the Petro-Chem Development Company after having spent some 30 years with Wilson-Snyder Manufacturing Company, from which he retired the first of this year.



A. H. Sherwood

● **Gordon L. Edwards** has been appointed vice president of the United States Steel Corporation. He will continue to serve as treasurer, the position he has held since 1927.

● **Colonel Ame Vennema,** on leave of absence with the U. S. Army for five years, has rejoined Schlumberger Well Surveying Corporation and has been appointed assistant to the Louisiana division manager in charge of gun perforating and allied services. The Louisiana division maintains headquarters in New Orleans. Before entering the army in December 1940, Vennema was stationed at Houma, Louisiana, where he was employed as an electrical logging engineer for Schlumberger.

Ame Vennema

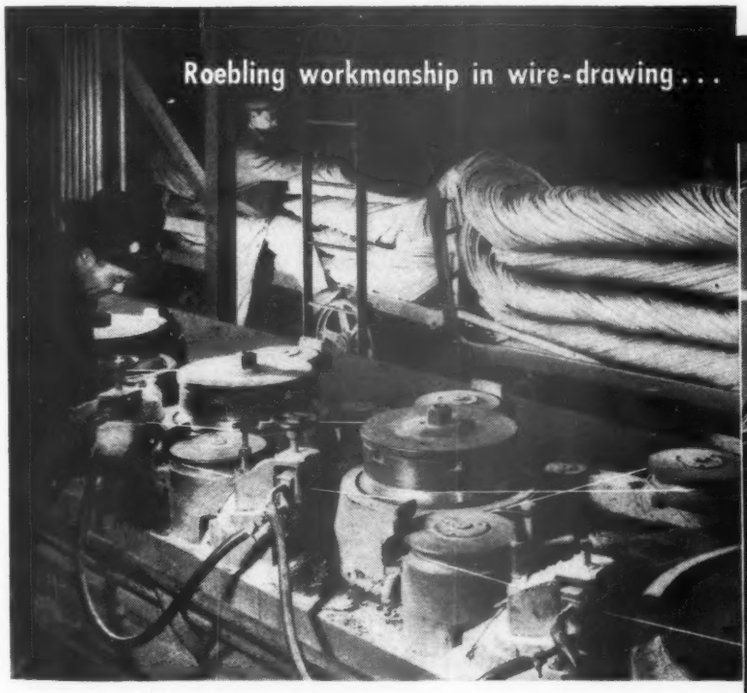
● **R. H. Davies** has been appointed consulting engineer in charge of the educational work of The Lincoln Electric Company of Cleveland, Ohio. Davies has been the Lincoln representative in Washington, D. C., where he did consulting engineering work with the Army, Navy, and other government agencies.

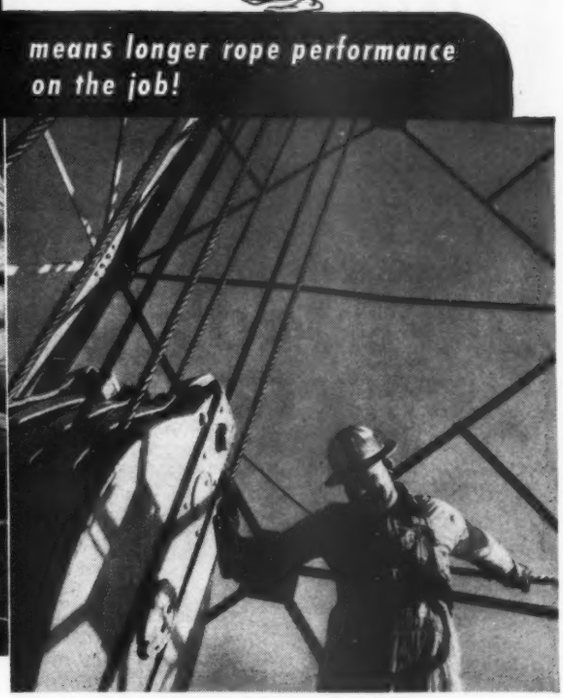
● **J. C. (Jack) Barcklow,** for many years division sales manager of the Mid-Continent Division of Lane-Wells Company at Oklahoma City, has recently been transferred into the general sales department to fill the newly created position of research geologist with office in Dallas, Texas.

● **Russell Milham** has been appointed district sales engineer for Hammel-Dahl Company of Providence, Rhode Island, designers and manufacturers of automatic control equipment, in charge of its Chicago and Mid-West district. Milham joined the Hammel-Dahl sales department in 1943, after graduating from the Northeastern University, and later, for several years, was instrument engineer and chemist at the E. B. Badger and Sons and Colonial Beacon Oil Company. His address is 447 Monadnock Building, 53 West Jackson Boulevard, Chicago 4, Illinois.

Rig with the right Rope
TO HELP CUT DRILLING COSTS

OLD MAN COMPETITION IS GETTING READY...





OTHER FUELS are trying to outsell petroleum. And while wells are going deeper and deeper for more production, drilling costs must not climb too high.

One way to help hold down operating costs is to rig with Roebling "Blue Center" Steel Wire Rope. Here's a tough rope that takes abrasion, shocks and strains—and *keeps going!* Specify it in the *right* construction . . . to reduce replacement time and costs on your rotary drilling, winch, casing and tubing lines.

Whether *your* needs can be met with more over-all economy by using preformed or non-preformed, Roebling engineers can help you save . . . with experienced advice on rope selection, installation and operation. Ask our nearest branch office about it.

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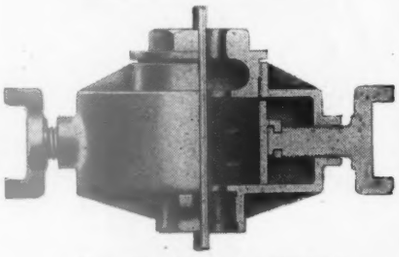
TRENTON 2, NEW JERSEY
Branches and Warehouses in Principal Cities

WIRE ROPE AND STRAND • FITTINGS • SLINGS • SUSPENSION BRIDGES AND CABLES
COLD ROLLED STRIP • HIGH AND LOW CARBON ACID AND BASIC OPEN HEARTH STEELS
AIRCORD, SWAGED TERMINALS AND ASSEMBLIES • AERIAL WIRE ROPE SYSTEMS • ROUND AND SHAPED WIRE • ELECTRICAL WIRES AND CABLES • WIRE CLOTH AND NETTING

ROEBLING
PACEMAKER IN WIRE PRODUCTS

Say "DOUBLE E"
WHEN YOU WANT .... The Best

SUCKER ROD STRIPPER



The "Double E" Adjustable Sucker Rod Stripper is the most economical and practical tool of its type. It not only does an excellent job of cleaning oil and paraffin from sucker rods as they are being pulled, but it has the very fine advantage of having retractable rubbers which can be withdrawn into the housing when not needed for stripping. This permits a long rubber life and also permits adjusting the rubbers against the rods to compensate for normal wear. The packing elements are of soft rubber (two halves) and readily accommodate any size rod or coupling. An examination of the cut shows how the packing is screwed against or backed away from the rods.

"DOUBLE E" Products
EQUIPMENT ENGINEERS
INCORPORATED
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DALLAS 9, TEXAS

Heads Overseas Petroleum

E. M. Butterworth, who has a wide background of experience in foreign and domestic producing activities, has been elected president of American Overseas Petroleum Company. He succeeds E. A. Skinner, who has returned to Standard of California as a member of vice president J. H. MacGaregill's staff.

E. M. Butterworth

Butterworth was graduated in geology from the University of California in 1916 and the following year, joined Standard of California as a geologist in the Santa Maria area in California.

Subsequently, his work took him to the Rocky Mountains, Alaska, Madagascar, and the Dutch East Indies. In 1925 he returned to the United States as district geologist for Standard in Los Angeles, and in 1936 became assistant manager of the foreign producing department, with headquarters in San Francisco.

During the war, Butterworth spent two years in the East on leave of absence from Standard as a special representative for the Petroleum Administration for War.

In July, 1944, he became a vice president of American Overseas Petroleum Company at the time this company was formed. American Overseas manages foreign exploration and development activities of companies jointly owned by Standard of California and The Texas Company, with the exception of their Arabian and Bahrein interests.

Tulsa representative

John W. Woods, fieldman from the Tallahassee, Florida, area, has recently been transferred to the Halliburton Oil Well Cementing Company office in the Philtower Building, Tulsa.

John W. Woods

Woods, who has been with Halliburton on the Gulf Coast and in Florida, will act as district representative, being well versed in the many phases of Howco well-servicing, which include acidizing, cementing, plastics, and oil base muds.

Wagner Electric changes

Wagner Electric Corporation announces branch manager and sales territory changes in its electrical sales division. The Kansas City territory has been divided into two parts. The southern portion, comprising Texas, Oklahoma, and parts of New Mexico, Arkansas, and Louisiana, is now the Houston branch office territory, with sub-

COMPLETE
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FOR ALL TYPES OF ENGINES

- Built to specications for either Diesel or gas engine applications. Safeguard engines against excessive water or lube oil temperatures, insufficient lube oil or water pressure, or other factors as desired.
- All parts of sturdy construction to withstand severe shock and vibration.
- Long years of specialized engineering knowledge in building *complete* Alarm Systems, for many varied applications, enables us to provide any desired arrangements.

Literature upon request.

One of many VIKING Visual Indicators available to meet specific control requirements—"tailor-made" units at "ready-made" prices.

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"Best Bet Yet"

These oil-proof, wear-resistant, plastic tubing protectors are an integral part of the tubing collar. Made in all sizes, they prevent the metal-to-metal contact that has caused many expensive "wet" jobs in pumping wells in the past.

PATTERSON-BALLAGH
TUBING PROTECTORS
LOS ANGELES 1 • HOUSTON 10 • NEW YORK 6

offices at Dallas and Tulsa, with L. J. Dicianne as branch manager.

The northern portion continues to be known as the Kansas City branch office territory and is now limited to Kansas and Nebraska and the western halves of Iowa and Missouri, with A. G. Viola as branch manager. Viola was transferred from Pittsburgh territory where he was branch manager since 1939.

J. L. Pasher, for many years manager of the Pittsburgh Automotive division branch territory, is now in charge of both the electrical and automotive divisions there.

New headquarters

To provide more convenient facilities for serving its customers throughout the central and eastern states, and users of engines and compressors equipped with Vortox oil-bath air cleaners, Vortox Company has moved its eastern headquarters from Detroit to 405 Immanuel Building, 2326 South Michigan Avenue, Chicago 16, Illinois, phone number Calumet 8620. Both O. A. Lohrke and his associate, N. B. Hedden, eastern representatives of Vortox, will make their headquarters in this new Chicago office.

Bill Wilson returns

W. A. Wilson

The many friends of Captain W. A. "Bill" Wilson will be glad to hear of his return to Web Wilson Oil Tools after 3½ years' service in the ordnance department of the United States Army.

Bill, under the direct supervision of his father, Web Wilson, will be in charge of new development work, engineering, designing, and manufacturing.

Heads Division

E. W. (Al) Forrow has been named manager of the Oil Equipment Division of Harvey Machine Company. He has been general sales manager.

"Al" Forrow's work in the oil and oil equipment business goes back to 1919, and includes work with Union Oil Company, Byron Jackson Company, and 11 years as vice president and general sales manager of Security Engineering Company, Inc.

The Oil Equipment Division of the Harvey Machine Company will produce and promote Harvey's own patented items of pumping equipment. Of immediate interest is the new Harcraft Hydro Pneumatic Pumping Unit, now reaching the market after extensive tests.

Mr. Forrow will also work with Harvey's Electronic Division.

W. H. Collins promoted

William H. Collins has been made assistant sales manager for Cameron Iron Works, Inc., Houston, Texas. In 1925 Collins withdrew from the University of Texas to work as a roughneck for the Shell Oil Company and later served as field superintendent for that company in several of its Gulf Coast fields.

W. H. Collins

Leaving Shell in 1935, he spent 5 years in leasing and royalty work, oil tool sales, and as a consultant in oil production. Collins represented Gray Tool Company in Louisiana for a year and a half and was later associated with the Arrow Drilling Company in Mississippi as a driller, leaving that position to serve as an analyst for the Petroleum Administration for War in Washington. Before assuming his present position with Cameron, he was an assistant director in PAW.

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...for those "Straight Holes"

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for Accurate Determination of Drift and Direction

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for proper tool placement

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"all-purpose" oriented or wire line

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for deflection work in pipe or open hole

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for "bullseye" directional jobs

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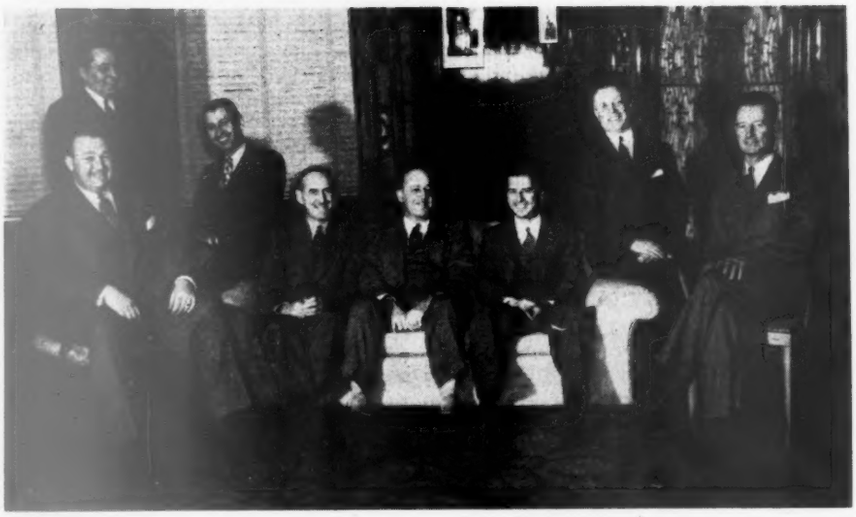
Justrite Twin-Bulb Safety Lantern Leads in the Petroleum Industry—Gives Long, Satisfactory Service

You can't buy a better portable light than this all-purpose Justrite Electric Lantern Model No. 44-S. It's stood the test of time and won the approval of men who know good lights—it's approved by Underwriters' Laboratories, Inc., and by the U. S. Bureau of Mines. This Justrite Electric Safety Lantern has two bulbs in its "kick-out" bulb sockets that immediately eject a broken bulb. Fixed sparkproofed guard protects face of lantern. Body of lantern swings on center pivot, permitting beam to be focussed up, down, or at any angle desired. Movable handle can be moved to any position around lantern. Here's the portable electric lantern that's "Justrite"!

Available now!—from your regular supplier.

JUSTRITE MANUFACTURING COMPANY
2063 N. Southport Ave., Dept. G-2, Chicago 14, Ill.



1946 officers Tulsa Nomads

NEW OFFICERS TULSA CHAPTER NOMADS. (Left to right)—Shep Miers, manager of Southwest Supply Company, regent; Gene Elder, assistant Mid-Continent manager, Pittsburgh Steel Company, deputy sergeant-at-arms; Mitchell Tucker, The Oil and Gas Journal, secretary; M. D. Gilbert, district manager, Pittsburgh Equitable Meter Company, treasurer; Henry Bourne, district sales manager, Republic Steel Corporation, president; W. G. Green, president of Engineering Laboratories, Inc., regent; Earle E. Smith, district sales manager, National Tube Company, assistant secretary; J. H. Eustice, president of W. C. Norris Manufacturer, Inc., sergeant-at-arms. Officers absent from the picture include Russell Hunt, attorney, vice president, and K. O. Hoevel, district sales manager, National Supply Company, assistant treasurer.

Made sales manager

Appointment of Kurt Sprengling as commercial sales manager of Crosley Motors, Inc., has been announced by Powel Crosley, Jr., president.

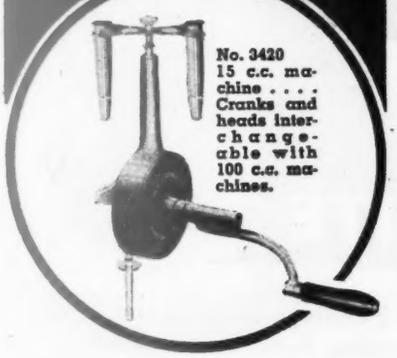
Before joining Crosley Motors, Inc., in January of this year, Major Sprengling was stationed in Detroit at the Office of the Chief of Ordnance, Development Division, specializing in small engine development for auxiliary power and engine generator units used in tanks and transport vehicles. He is a graduate of mechanical engineering of the University of Illinois and holds a master's degree of science in petroleum engineering from the University of Kansas where he was awarded a Spang Fellowship.

National sales manager

The Shafer Bearing Corporation of Chicago announces the appointment of Major O. W. Schmidt as national sales manager of the company. He will be responsible for the development and maintenance of a field organization that will supplement and assist the sales promotional efforts of Shafer representatives and distributors.

An engineering graduate of Iowa State College, Major Schmidt became a sales engineer for a large machinery and supply company where he spent several years in successful sales development work with dealers and customers of that firm. In 1942, Schmidt became assistant chief of the production division, central district, of the Air Technical Service Command, Army Air Forces. As such, he was responsible for the production and procurement of all aircraft and aircraft parts manufactured in the central district. This activity led to intimate familiarity with the processes and product of anti-friction bearing manufacturers throughout the country, including the Shafer Bearing Corporation. The appointment of Major Schmidt is an important part in the new Shafer program.

For QUICK, ACCURATE TESTS
Use CURTIN CENTRIFUGES



No. 3420 15 c.c. machine . . . . Cranks and heads interchangeable with 100 c.c. machines.

Simple in design . . . Ruggedly built . . . Require no special care . . . Great Ratio and throw of crank produce required speed with no strain. Curtin Centrifuges meet all *A.S.T.M. Standard Method D-96-40* and *A.P.I. Code No. 25* requirements. Fully descriptive literature upon request.

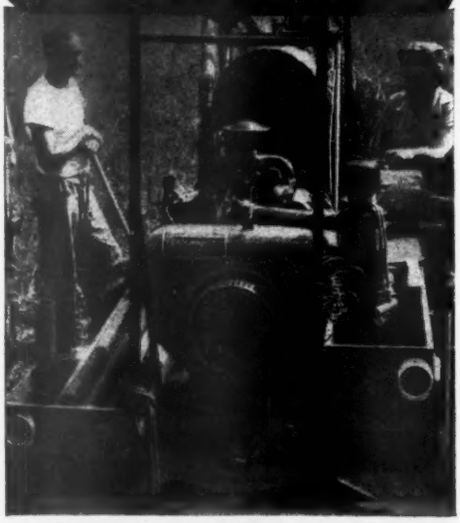
W·H·CURTIN & CO. Inc.
HOUSTON U·S·A TEXAS

The picture shows a Model VE4 Wisconsin V-type, 4-cylinder Air-Cooled Engine powering a Casperson Core Drilling Unit, engaged in oil field exploratory work.

This engine, weighing in at 295 lbs., turns up 22 hp. at 2600 rpm. and is built for rugged, heavy-duty service. It is equipped with Timken tapered roller bearings at both ends of the crankshaft to assure fullest protection against bearing failure under continuous, full-load operation and to take up end-thrust.

Core Drilling is "duck soup" for this engine . . . just one of any number of jobs Wisconsin Air-Cooled Engines are handling in oil field service, with top efficiency, operating economy and heavy-duty dependability.

Core Drilling is "Duck Soup" for this WISCONSIN HEAVY-DUTY *Air-Cooled* ENGINE



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World's Largest Builders of Heavy-Duty Air-Cooled Engines

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Oil field distributors for Wisconsin Engines and all types of utility units.

Book Reviews

● **Catalytic Chemistry,** *by Henry W. Lohse. Published by Chemical Publishing Company, Inc., 26 Court Street, Brooklyn 2, New York. Pages, 416. Price, $8.50.*

Here is a book of general interest to every chemist, chemical engineer and technical worker in all industries. Its aim is to present factually the underlying principles of catalytic phenomena and the application of catalytic reactions in industrial processes. Particular attention has been paid to the presence of impurities, in catalytic reaction systems, and to the role of traces of other metals in silver, copper, iron, nickel, etc., used as catalysts.

The author, Henry W. Lohse, consulting chemist, has devoted a separate section to each of the various types of catalytic reactions. The nature and properties of catalysts, as well as industrial catalytic reactions have been discussed in detail. Many clear illustrations will help in the understanding of little understood phenomena.

● **Ball and Roller Bearing Engineering,** *by Arvid Palmgren. Translated by Gunnar Palmgren and Bryce Ruley. Published by SKF Industries, Inc., Philadelphia, Pennsylvania. Pages, 257.*

This qualified presentation of modern bearing theory and practice is intended to serve as a fundamental text; it is neither a comprehensive treatise nor a bearing catalog. It is an orientation on the principles of ball bearing engineering and in order to simplify the text, Palmgren, Doctor of Engineering at SKF in Sweden, has omitted derivations and calculations which require a knowledge of higher mathematics.

"Ball and Roller Bearing Engineering" is divided into the following 9 sections: 1. Common Bearing Types. 2. Forces and Motions in Bearings. 3. The Carrying Capacity of Ball and Roller Bearings. 4. Bearing Selection. 5. Design of Bearing Applications. 6. Mounting and Dismounting. 7. Lubrication and Maintenance. 8. Bearing Failures. 9. Table.

● **A.S.T.M. Standards on Petroleum Products and Lubricants.** *(October, 1945.) Prepared by A.S.T.M. Committee D-2. Published by American Society for Testing Materials, 260 S. Broad St., Philadelphia 2, Pennsylvania. Pages, 530. Price, $2.75.*

Over 80 specifications, tests, and definitions that have been standardized through the work of Committee D-2 on Petroleum Products and Lubricants have been brought together in convenient form in this latest compilation of A.S.T.M. Standards on Petroleum Products and Lubricants.

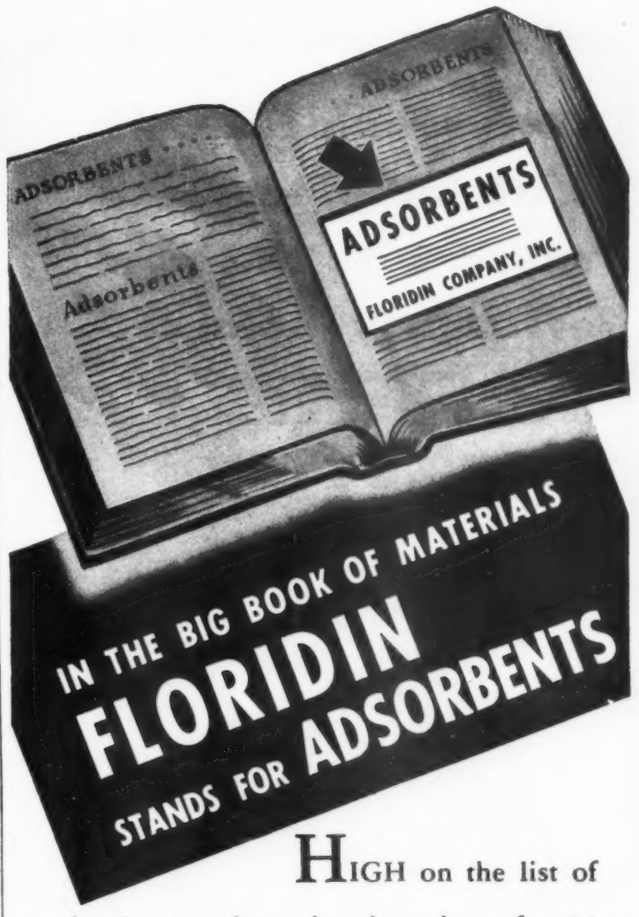
There are, in addition to the current report of the committee, several appendices covering the following: results of tests on method for estimating maximum pour points of lubricating oils containing pour point depressants, and two proposed methods covering a test for maximum pour point and total olefinic and aromatic hydrocarbons in gasoline.

Authoritative procedures for determining properties of a wide range of petroleum products, for example, acid heat of gasoline, aniline point, ash content, autogenous ignition temperatures, aromatics, olefins, benzene and isopentane insolubles, crankcase oils, knock characteristics of fuels, specific gravity, color, distillation, melting point, viscosity-temperature charts (Saybolt and kinematic), etc., are provided by the large number of test methods.

● **The Efficient Use of Fuel.** *Prepared under the Direction of the Fuel Efficiency Committee of the Ministry of Fuel and Power. Published by Chemical Publishing Company, Inc., Brooklyn, New York. Price, $8.50. Pages, 787.*

Here is an unusually complete text, embracing the use of all fuels for industrial purposes. The composition and properties of all types of fuel, and the theories and principles of combustion are explained very clearly. The equipment used in burning all types of fuel, scuh as coal and other solid fuel, fuel oil and industrial gases, is authoritative and detailed.

Each chapter has been submitted for criticism and revision to panels of experts on the particular subjects under review.



HIGH on the list of adsorbents, where they have been for 35 years, you will find Floridin products. In the making of aviation gasoline, lubricating oils, synthetic rubber, and many chemicals, the most advanced and the most exacting processes are giving new proof of the effectiveness of these adsorbent products. A staff of technicians is employed to give aid and advice as users may require. If you have a problem of adsorption—dehydration—decolorization—catalysis, your inquiry will be given careful, competent attention

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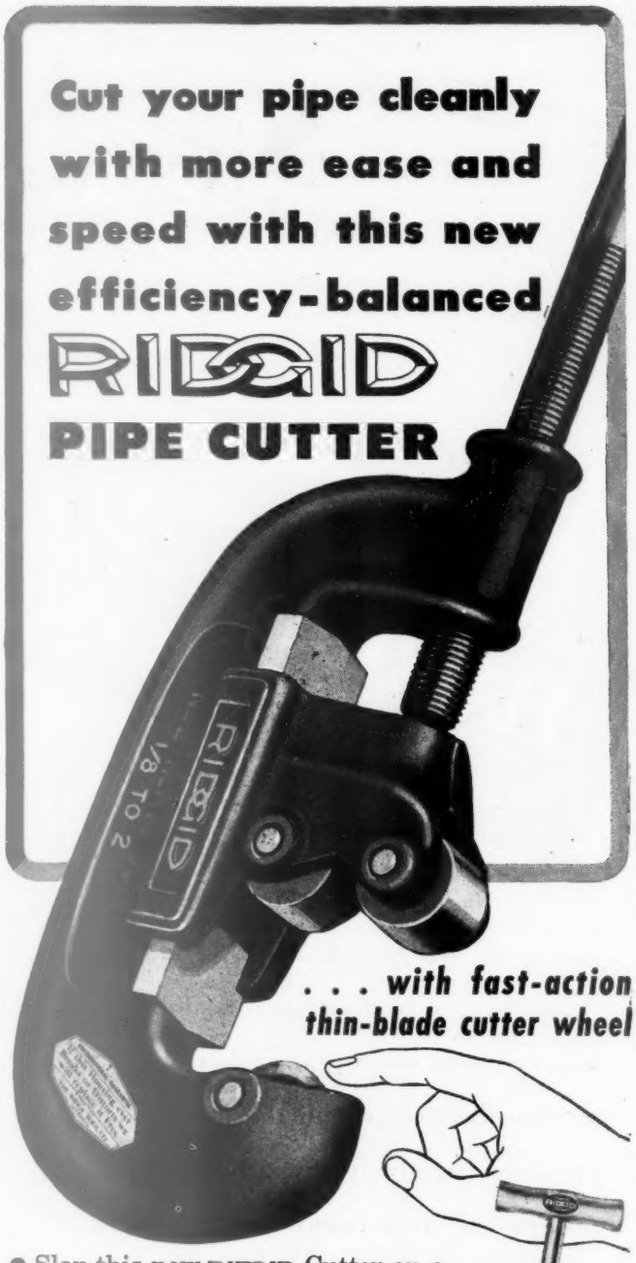
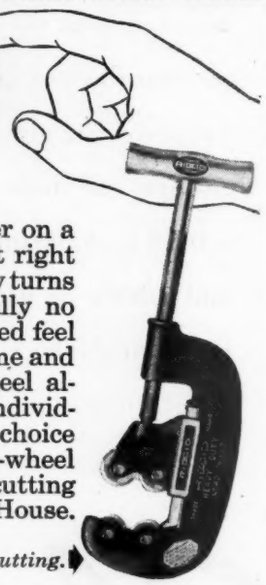
Cut your pipe cleanly with more ease and speed with this new efficiency-balanced

RIDGID

PIPE CUTTER



. . . with fast-action thin-blade cutter wheel



● Slap this new RIDGID Cutter on a pipe, turn it tight and roll it right through your pipe in a few easy turns — thin wheel leaves practically no burr. You like the well-balanced feel of its new style malleable frame and the thin blade tool-steel wheel always cuts true—every cutter individually tested to assure it. Your choice of 5 sizes to 6" capacity and 4-wheel cutters to 4." For easier pipe cutting order RIDGIDs, at your Supply House.

4-wheel No. 42 for fast quarter-turn cutting.

RIDGID

WORK-SAVER PIPE TOOLS

THE RIDGE TOOL COMPANY • ELYRIA, OHIO, U. S. A.

Kerr named vice president

A. J. Kerr, formerly general sales manager, has been elected vice president of sales of the Rockwell Manufacturing Company, Pittsburgh, Colonel Willard F. Rockwell, president and chairman, has announced.

A. J. Kerr

Kerr has been associated with the company for more than 20 years. His early career was as district manager, Tulsa office of the Pittsburgh Equitable Meter and Nordstrom Valve companies, now divisions of the Rockwell Manufacturing Company. In 1944 he was made general sales manager.

As vice president of sales of the Rockwell Manufacturing Company, Kerr will coordinate the marketing activities of the various subsidiaries and divisions. These include Pittsburgh Equitable Meter Division, Nordstrom Valve Company, Rockwell Machine Company, The Delta Manufacturing Company, The V & O Press Company, Edward Valves, Inc., The Crescent Machine Company, Rockwell International Corporation, Monessen Foundry and Machine Company, and Arcade Manufacturing Division.

Heads Larkin California sales

C. F. "Cliff" Warner has been appointed California sales representative and will devote his entire time to the sales and servicing of Larkin Packer Company's line in California.

Warner has had 22 years' experience in the cementing business. He started with the Perkin's Cementing Company in 1923 and was promoted to district manager 5 years later and again to field manager in 1938, a position he held until the company was sold in 1940.

In the latter part of this same year he became employed by International Cementers, Inc., and was promoted to district manager a year later, a position he held until his recent resignation.

Larkin Packer Company, with headquarters in St. Louis, Missouri, manufactures a complete line of cementing equipment including cementing shoes, float collars, packers, casing equalizers, casing clamps, tubing and casing heads, bull plugs, swage nipples, and a new item known as a cementrol shoe.

Warner will cover the entire state and will maintain offices at the Howard Supply Company, 5125 Santa Fe Avenue, Los Angeles, California, distributors, according to an announcement by W. H. Larkin, president.

New heads Roots-Connersville

Election of J. S. Tatman as chairman of the board and John Avery as president and general manager of Roots-Connersville Blower Corporation, Connersville, Indiana, one of the Dresser Industries, was announced following the recent meeting of the directors of this company.

Tatman has been with Roots-Connersville since his graduation from Purdue University in 1902. He is a vice president of The Compressed Air and Gas Institute.

Avery, well known for his activities in centrifugal compressor engineering for the last 22 years, was graduated from the U. S. Naval Academy in 1923. He then joined the engineering staff of General Electric Company and in 1926 became a project engineer for American Brown Boveri Company. Before becoming president of Roots-Connorsville, Avery was manager of the blower and compressor department of Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin.

New pipe line construction

Vaughn and Taylor Construction Company of Wichita Falls, Texas, will begin work about April 15 on approximately 75 miles of 12-in. gasoline loops for Phillips Petroleum Company between Borger, Texas, and Wichita, Kansas.

This construction company has just completed about 55 miles of lines for Phillips in the Fullerton field and for Huber Gas Corporation at Borger.

Associates in the company are Dillard D. Vaughn, Jess Moore, R. L. Taylor, A. J. Harris, and Joe Randall Allen.

Company recapitalizes

W. A. Olen

The Four Wheel Drive Auto Company of Clintonville, Wisconsin, has announced a recapitalization program consisting of the sale of 14,233 new shares of stock to be followed by a stock allotment of 100,000 shares, according to Walter A. Olen, president of the company. Capitalization of the company, after distribution of these two blocks of stock, will be 300,000 shares with a par value of $3,000,000. Prior to the stock sale and allotment, capitalization of the company was for 185,767 shares with a par value of $1,857,670.

To add new division

Brown and Root, Inc., one of the oldest firms of engineers and constructors in the Southwest, announce the expansion of their industrial services through the creation of a petroleum and chemical division, specializing in the design, engineering, and construction of process plants for the oil, gas, and chemical industries.

The firm has done a wide range of work in these fields for more than a decade, including construction of chemical plants, compressor stations, pumping stations, pipe lines, gathering systems, and the rendering of general utility services. Among other jobs, it built one of the largest chemical works in Texas, a plant for the production of anhydrous ammonia.

The new division will round out the firm's services in these fields, by enabling it to perform every step in the creation of process plants, from plant location studies, through engineering design, construction and operation, to completion. It will be able to perform all or any phases in completion of natural gasoline plants, cycling plants, compressor stations, dehydration plants, gas treating plants, vapor recovery plants, installations for fractionating and treating of refinery vapors, refinery units, and chemical plants.

Offices for design and engineering and shops for fabrication work of the new division will be at the Greens Bayou plant of the Brown Shipbuilding Company, Inc., and will be in addition to the yard's shipbuilding, ship repair and drydocking services for the Navy and private shipping interests, and steel fabrication, which will continue.

In charge of the new enterprise with the title of manager will be Milton H. Roths, who in October, 1945, was placed on inactive status with the U. S. Naval Reserves with the rank of commander, after 20 months of service in World War II.

Roths has had 16 years of experience in design, engineering, fabrication, and construction of process plants.

Process engineer for the new division will be F. W. Bell, who has had 10 years' experience as a refinery technologist, and in design, engineering, and construction of process plants since his graduation from the University of Michigan in 1936.

Howard M. Anderson is engineer for the new division. He has had 20 years' experience in the line of work he will follow.

Sixteen years of unqualified success in the design and manufacture of Communication, Telemetering, Signal and Control Equipment "tailored" to fit the needs of the petroleum industry.

SO. ELECTRIC & TRANSMISSION CO.

Engineers and Manufacturers

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Carrier Equipment for Telephone, Telegraph, Telemetering, Signal and Control Service.

Voice Repeaters • Special Transformers
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Your pipe threading takes less time and effort with THIS direct-action No. 1R

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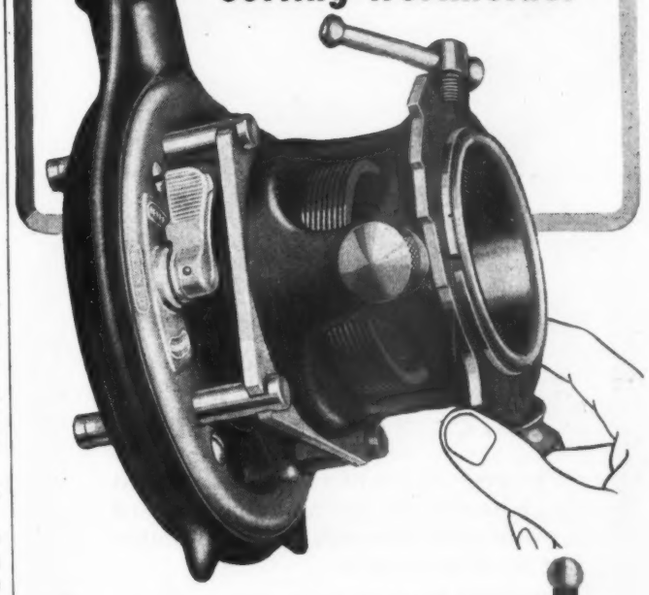
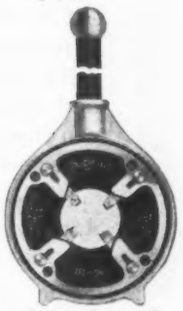
Threads 1" to 2" pipe
Full-floating posts

Bushingless, quick-setting workholder





• If you prefer a poster threader, here's an improved one that's ready to thread 1", 1¼", 1½" or 2" pipe most quickly and with least bother. Quick-set foolproof workholder has no bushings to bother with. No cockwobble in threading—handle pulls head and dies directly, floating posts merely taper thread, do no driving. Alloy or high-speed steel chaser dies cut clean perfect threads, steel and malleable construction assures long service—and it sells at a popular price! . . Buy No. 1R at your Supply House.

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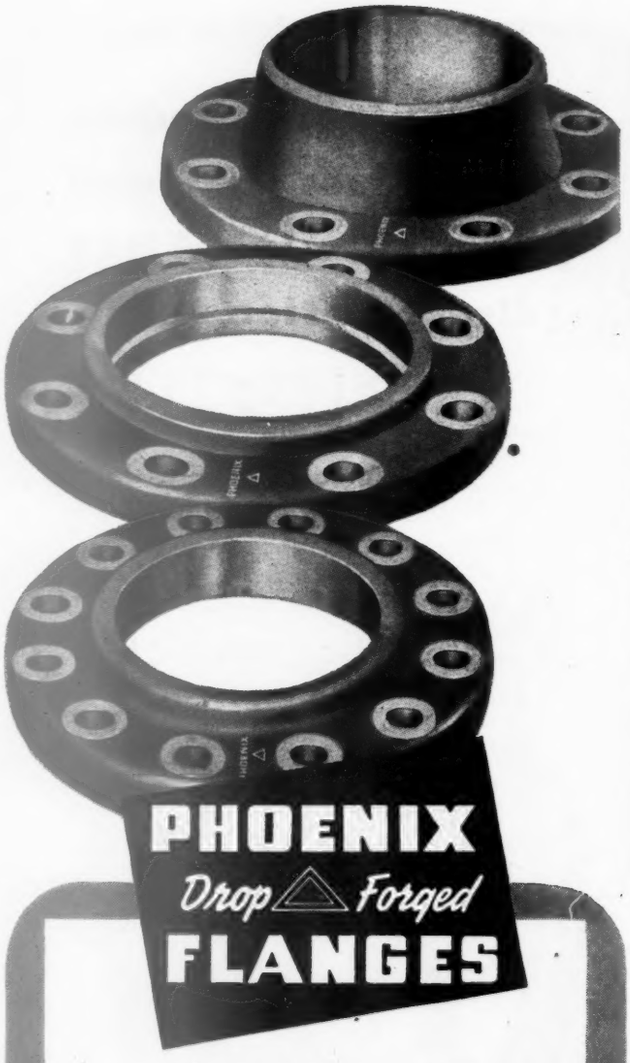
WORK-SAVER PIPE TOOLS

THE RIDGE TOOL COMPANY • ELYRIA, OHIO, U. S. A.



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Wherever the use of a flange is required . . . whatever the size and type specified . . . there's a Phoenix Flange available for the exact purpose.

Phoenix Flanges are drop forged from mild steel especially suited to welding and machining. When specified, they can be supplied in Stainless Steel, Everdur brass and other alloys.

Every Phoenix Flange complies with ASA requirements and ASME and ASTM specifications.

For safety, service and satisfaction specify Phoenix Flanges. Write for your free copy of the new Phoenix Flange Catalog today.

Flange Division of

PHOENIX MANUFACTURING COMPANY

Catasauqua, Pennsylvania — Joliet, Illinois

The average pipeliner is an intense sort of individual whose working hours are crowded with the complex problems of speedy disposal, rational segregation, and adequate storage. Wells come in at the most inopportune moments and in the most unexpected places, like red spots on a measles patient, and the pipeliner dashes hither and yon, laying a line here, installing a pump there, and setting up storage somewhere nearby in order that the system may remain completely operable. His nights are a jangle of insistent phone bells and urgent consultations, and when he does fall off to sleep, it is to dream of overflowing tanks, overtaxed lines, leaks, etc., until he is finally engulfed in a flood of oil that he is striving desperately to confine in a milk bottle. He works at a pressure of about 750 lb per sq. in., and it is fortunate that in most instances he is wise enough to supply himself with a relief valve, in the form of some hobby or diversion, to obviate the possibility of blowing his top.

●

Take Walter Roberts, for instances, Shell Oil Company's assistant superintendent in the L. A. Basin, known as "Bob" to every pipeliner in Southern California. He was chief dispatcher for so many years that his voice is as familiar to oilmen as is that of Sinatra to the bobby soxers. Besides knowing exactly how much oil it takes to exactly fill 4 miles of 10-in. line, Bob is well versed in the horticultural and agricultural arts. He was the first in the field to realize that it is foolish to put double petunias in single beds, and is credited with the remarkable development of the cucumberry, a cross-polonization product that is very much larger than a strawberry and very much smaller than a cucumber.

●

Clyde Swigart, manager of Standard of Cal's pipe line department, seeks refuge from the weight of his occupational responsibilities on a cattle ranch up in the Santa Maria district, and to all appearances is profiting in a physical way at least by the seeking. There is something peculiarly fascinating about farm life—we simply love to watch a razorback hog stropping itself against a tree, and we cherish the hope that some day we, too, will have a ranch with some good pasture acreage, and stock it up with a herd of these political bulls from Washington, D. C.

●

There are several more ranchers among the California pipeliners. Fred Simms, division pipe line manager for Shell, has a place up in the Walker Pass country east of Bakersfield. And when he can tear himself away from the city, he hies out there, puts on his boxing gloves and does a bit of cow punching. Incidentally, his ranch is up in the wild flower country, which reminds us of another well known member of this exclusive sect —E. L. "Ed" Adams, pipe line chief for General Petroleum Corporation, who is considered something of an authority on California flora. We were simply knocked for a lupin by his statement that there is enough poison in 400 California poppies to kill eight adults, if California poppies were poisonous.

●

We forgot to mention among the cow punchers the man who originated deep in the heart of Texas and wears a five-gallon hat to prove it—Jack Pate, Union Oil Company's southern div supe. Here is a lad who can bulldog a steer or rope a calf as quickly as any experienced idol of the rodeos. And what is more, he is not too particular whose calf it is—so long as it is a shapely one. While we are in Union's camp, we might mention that Bill Hay, the pipe line chief, has two hobbies—photography and bridge. He claims that he became a camera addict to teach himself snap judgment, and then he had to take up bridge to subsidize the cost of the photography.

●

Frank Coyle, the Tide Water Associated pipe line head finds surcease from his business worries in the worries of golf. We

have it on good authority that he has invented an ingenious gadget with which it is possible to distinguish almost immediately between a dust storm and an oil man's golf tournament. Last time out, Frank thought he had made a 300 yard drive until he looked down and saw that the ball was still there and his wrist watch was gone.

●

Also given to scarring the good earth is Joe Josef, Standard's southern division superintendent. Joe usually tosses a coin on Sunday mornings to help him decide whether to go to the church or the golf links, and frequently has to toss it 12 or 14 times before he can leave for the links.

●

A sportsman of diversified taste is Mac McKeany, Shell's chief dispatcher, who not only waves a mean club at a golf ball but also excells in skittle mayhem or alley bowling. He admits that if his bowling score were as high as his golf score and his golf score were as low as his bowling score, he could give both Byron Nelson and Ned Day a run for their money. Another bowler of repute is John Sleeth, Union's chief gauger, who throws one of the fastest balls known to the sport. When he rolls a strike, he only knocks down a few of the pins with the ball, the rest are shaken down with the jolt he gives the building.

●

The unique pastime enjoyed (?) by Ralph Paine, Standard's southern division chief, is hunting—hunting a home. So far he hasn't bagged a thing, but he has sneaked up pretty close to one or two big ones lately only to see them slip off the hook at the last minute. He is reducing now in the hope of finding a breakfast nook that will fit him. By the way, among the agriculturists we missed Manford Alcorn, who officiates over the southern division for Shell. Without ever planting a seed, he raises things called divots that are remarkable for their size and weight, and command a good price in the real estate market for building sites. It is done by using an eight iron and keeping your eye off the ball.

●

Howard Robinson, Union Oil Company's Valley chief, has a yen for civic improvement, and is a gifted speaker with a vocal intonation and enunciation that would have made him a fortune in radio. On top of all that he is a swell citizen. So also is that inexhaustible fount of miscellaneous information about oil and oil people—Art Smothers of Standard Oil Company of Cal., whose hobby has long been the practice of friendliness and helpfulness wherever the opportunity presented. If to give is better than to receive, Art has had a pretty good time over the years.

Milener to A.G.A. staff

Eugene D. Milener has been appointed coordinator of general research of the American Gas Association effective March 1, it has been announced by H. Carl Wolf, managing director of the Association. At the same time, Mahlon A. Combs was promoted from assistant secretary of the Industrial and Commercial Gas Section to secretary, succeeding Milener in this post.

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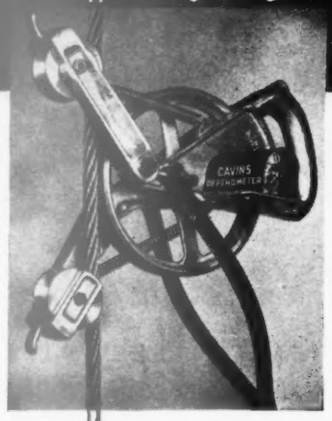

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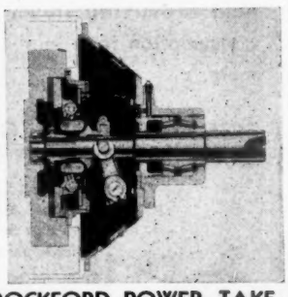

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Named N. Y. sales manager

P. H. Lair

The Dampney Company of America, Hyde Park, Boston, announces the appointment of P. H. Lair, well known eastern industrial engineer and research consultant, as manager of its New York sales office, 114 Liberty Street, New York, where he will offer consultation and service in the field of protective coatings. Lair's experience fits him particularly for this position. For the last 5 years, he has been engaged in industrial and mechanical engineering for one of the larger eastern engineering firms.

Bailey engineers meet

District branch office managers of Bailey Meter Company and Bailey Meter Company, Ltd. of Canada met in Cleveland recently to study at first hand new developments in the company's line of meters and control.

Prominent among the new products discussed was the company's line of electronic type instruments. This includes resistance thermometers, potentiometer pyrometers, oxygen and combustibles recorders, telemetering systems, compensating and calculating systems, all greatly simplified and rendered particularly suitable for industrial service by the use of electronics.

Other discussions centered around the applications of both old and new products to the present day needs of steam power plants and process industries.

The many advantages of coordinating steam plant control systems for combustion, feed water, steam temperature, pressure reducing, condensate flow, and heater level into one unifid system, were discussed.

Electronic type process controllers for temperature, which are available for use with pneumatic, electric, or electronic control systems were featured for their sturdy construction, flexibility, and advanced design principles, which eliminate all continuously moving or vibrating parts from the measuring and control systems.

Make new affiliation

J. A. McPeak and R. P. Farrell recently acquired financial interest in Harper Packing Company, Inc., of Chester, Pennsylvania. They were formerly president and treasurer, respectively, of France Packing Company. They bring to their new company a combined experience of more than 50 years devoted to the design and manufacture of metal packing for all types of engines and compressors.

R. A. Durand

Durand promoted

Raymond A. Durand, formerly assistant sales manager of Edward Valves, Inc., East Chicago, Indiana, has been advanced to the position of sales manager, W. F. Crawford, president of the company, has announced.

Durand has been a member of the Edward engineering sales organization for more than 9 years. He attended Northern State Teachers College in Michigan, Indiana University, and the University of Chicago.

Dolan to New York

The appointment of Eugene Dolan to the New York City sales office of the Dayton Rubber Manufacturing Company has been announced.

Dolan, a member of the United States Marine Corps for 33 months, was connected with Standard Brands Corporation for 4 years prior to his military service.

He taught in the radar school at the Corpus Christi technical training center and was a member of the La Salle School faculty in Troy, New York. Dolan was also director of the Troy Community Center. He is a graduate of Notre Dame University.

Residing at 362 First Street, Troy, New York, Dolan will make his headquarters at Dayton Rubber Manufacturing Company, 11 Park Place, New York City.

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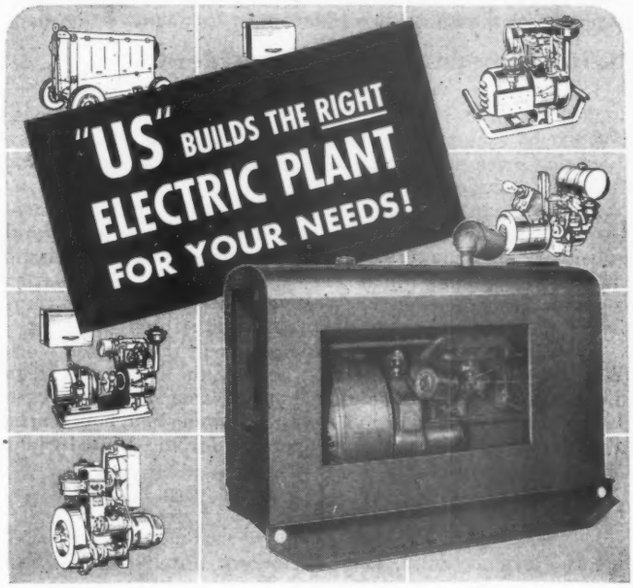

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PEERLESS PUMPS

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A Statement by FOOD MACHINERY CORPORATION in regard to *Dayton-Dowd*

An important advance in the history of the pumping industry now for the first time makes available a new conception of integrated pump service to customers. *Dayton-Dowd*, long associated with sustained high quality—a distinguished name on centrifugal pumps—has become an integral part of the *Peerless Pump* organization.

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PEACE-TIME BUILDERS OF TOP-FLIGHT WATER PUMPS

American Chemical Society meeting

Sessions dramatizing the impact of atomic power upon civilization will feature the 109th national meeting of the American Chemical Society, which, it is announced by Colonel Bradley Dewey, president, will be held in Atlantic City, New Jersey, April 8 to 12. The meeting, the first to be held by the society since 1944, will be the largest in the history of the American chemical profession, it is stated. Ten thousand chemists, chemical engineers, and industrialists will participate.

The program will include a broad survey of nucleonics, the new field of scientific endeavor dealing with the release of energy from the nucleus of the atom, under the chairmanship of Dr. Glenn T. Seaborg, co-discoverer of plutonium, one of the atomic bomb's bases, and also of elements 95 and 96. Dr. Seaborg, a University of California chemistry professor, is in charge of plutonium research for the Manhattan Project at the University of Chicago Metallurgical Laboratory.

Peacetime applications of many other wartime advances will be discussed. Developments in plastics, petroleum, rubber, food, gas and fuel, medicinal chemistry, education and other fields will be reported in the several hundred papers to be presented at sessions of seventeen of the Society's professional divisions. More than 10 local sections of the society will be represented.

Join Cummins staff

Sales representatives Edward M. Bonette and James R. Neal have joined the staff at Cummins Service and Sales, 1661 McGarry Street, Los Angeles.

Specializing in transportation and industrial engine installations, Bonette will cover territory north from Los Angeles to Santa Maria. Neal will be in charge of the district south to San Diego.

After attending Loyola University in Chicago, Bonette joined International Harvester Company. He was with this firm 13 years.

Neal, who attended Case School of Applied Science, comes to the Cummins sales organization direct from a three-year hitch in the Navy. Prior to donning a middy in 1942, he was associated for 9 years with the Euclid Road Machinery Company of Cleveland.

Senior operating vice president

L. E. Osborne, who joined Westinghouse at the age of 16 as a clerk in the tool room at the East Pittsburgh Works, recently was named senior operating vice president of the Westinghouse Electric Corporation, responsible to the president for all manufacturing units of the company.

In announcing the appointment, Gwilym A. Price, president, explained that Osborne's new responsibilities also include all subsidiary manufacturing companies as well as the district manufacturing and repair department and the headquarters manufacturing division of Westinghouse. His office is transferred to the company's Pittsburgh headquarters.

Throughout our nation's participation in the Second World War, Osborne was the directing head of the company's steam division at South Philadelphia, Pennsylvania, and since early 1943, he was also responsible for the adjoining merchant marine division, which Westinghouse operated for the United States Maritime Commission.

Death takes J. H. Courtner

J. Howard Courtner, 40, assistant general manager of Dowell Incorporated at Tulsa, and well known throughout the Mid-Continent oil industry died in a Chicago hospital recently from a stroke.

Courtner had been undergoing treatment in Chicago for the last several weeks and, in view of his rapid recovery, news of his death comes as a shock to his many friends and business associates.

Courtner, born in Oklahoma City, was educated in Oklahoma schools, where he attended both Oklahoma City University and the University of Oklahoma. He has been in the employ of Dowell Incorporated since August, 1934. He advanced with the organization from treating engineer to station manager at Hobbs, New Mexico, and, in April, 1939, to district manager of the Salem, Illinois, territory. In January, 1945, Courtner was transferred to the general office of the company in Tulsa where he held the position of assistant general manager.

Manton joins G.M. staff

Fred L. Manton, a 1937 mechanical engineering graduate of Oklahoma A. & M. College, has joined the General Motors petroleum industry sales staff, according to Arch F. Campbell, manager of the petroleum industry sales office of the G. M. Detroit Diesel Engine Division.

Manton was formerly a sales engineer for the National Supply Company, and a district manager of the Superior Engine Division of the National Supply Company at Fort Worth, Texas, until recently. With General Motors he will be district manager for the Detroit Diesel Engine Division petroleum sales in North and West Texas, northern Louisiana, and Mississippi. His home is in Fort Worth, Texas, although he may later locate in Dallas.

Heads gas division

W. B. Head, Jr., has assumed his duties as manager of the Houston division of the United Gas Corporation following retirement of K. L. Simons, head of the division since 1930, it was announced by United Gas vice president, J. V. Strange. After 44 years in the utility business, Simons, who is 67 years of age, retired to return to his native South Carolina to make his home.

James A. Wilson, who was manager of the United Gas Monroe, Louisiana, division was raised to assistant manager of the Houston division.

Receives Lucas Medal

James O. Lewis, petroleum engineer of Houston, Texas, was awarded the Anthony F. Lucas Medal by the American Institute of Mining and Metallurgical Engineers at the recent annual meeting of that organization in Chicago.

The presentation was made "for his pioneer work in laying the foundation of petroleum engineering through early recognition and lucid exposition of the energy relationships in petroleum reservoirs; for his vision and leadership in developing secondary recovery methods, and his large influence in the general improvement of petroleum production practices."

To Oklahoma U. staff

Announcement has been made by W. H. Carson, Dean of the College of Engineering, University of Oklahoma, of the appointment of Dr. Frank C. Fowler as assistant professor of chemical engineering. Dr. Fowler took his undergraduate work at the University of Illiñois and completed his masters and doctor of philosophy degrees at the University of Michigan. For the last 3 years he has been employed in th Chemical Products Department of the Phillips Petroleum Company.

Dr. Fowler's work at the University will be under the direction of Dr. R. L. Huntington, Director of the School of Chemical Engineering, and his time will be spent in teaching, research, and consulting.

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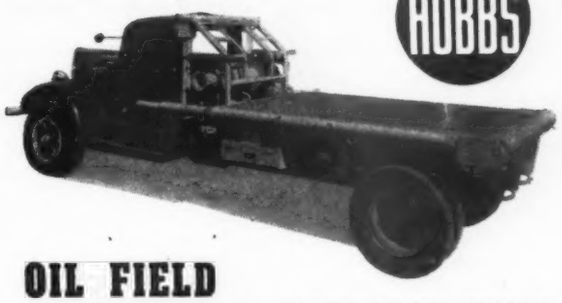

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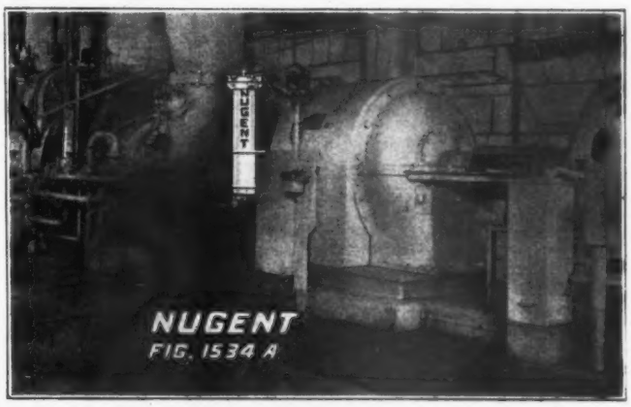

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THE METAL WARE CORP. TWO RIVERS, WISCONSIN

To cover world market

Comprehensive coverage of the world export market figures actively in merchandising plans of the Detroit Diesel Engine Division of General Motors Corporation, according to V. C. Genn, general sales manager, and Duncan Lamont, manager of overseas sales.

Detroit Diesel recently completed a five-day "refresher course" for the men who will be responsible for the sales and servicing of the GM Series 71 diesel engines abroad.

Talks were given by Detroit Diesel officials not only on GM diesel features and varied applications but also on distribution and potential markets. Three days were devoted to sales and two days to engineering and service.

Exclusive of the United States, Canada, and Alaska, the sales and service of the GM Series 71 engine will be handled entirely by the Oversas Division of General Motors under the direction of Earl E. Eby, sales manager of industrial and power equipment. GM Overseas representatives from the following countries attended the meeting: Sweden, Denmark, Belgium, France, India, Australia, Java, New Zealand, Brazil, Argentina, Mexico, Uruguay, Peru, Venezuela, Cuba, Chile, and South Africa.

The future of Venezuelan sales

A rapidly expanding export market in Venezuela for industrial goods, provided American selling methods are keyed to the local situation, is predicted by H. Gottwald, foreign sales executive of the Rockwell International Company, New York City.

Gottwald, just back from a market survey of the Venezuelan oil fields, feels that the development of this rich export market can only be held back by a lack of understanding of the problems peculiar to operation in Venezuela.

"First of all," says Gottwald, "wage rates for all types of native labor are very high, and living costs are very high. The petroleum companies that are operating in Venezuela are paying high concession prices for exploratory land. The Venezuelan government is putting on great pressure to increase substantially the percentage of native labor employed on all industrial projects. Transportation costs are high, not only to bring necessary equipment to Venezuela, but also to transport it to field sites within the country.

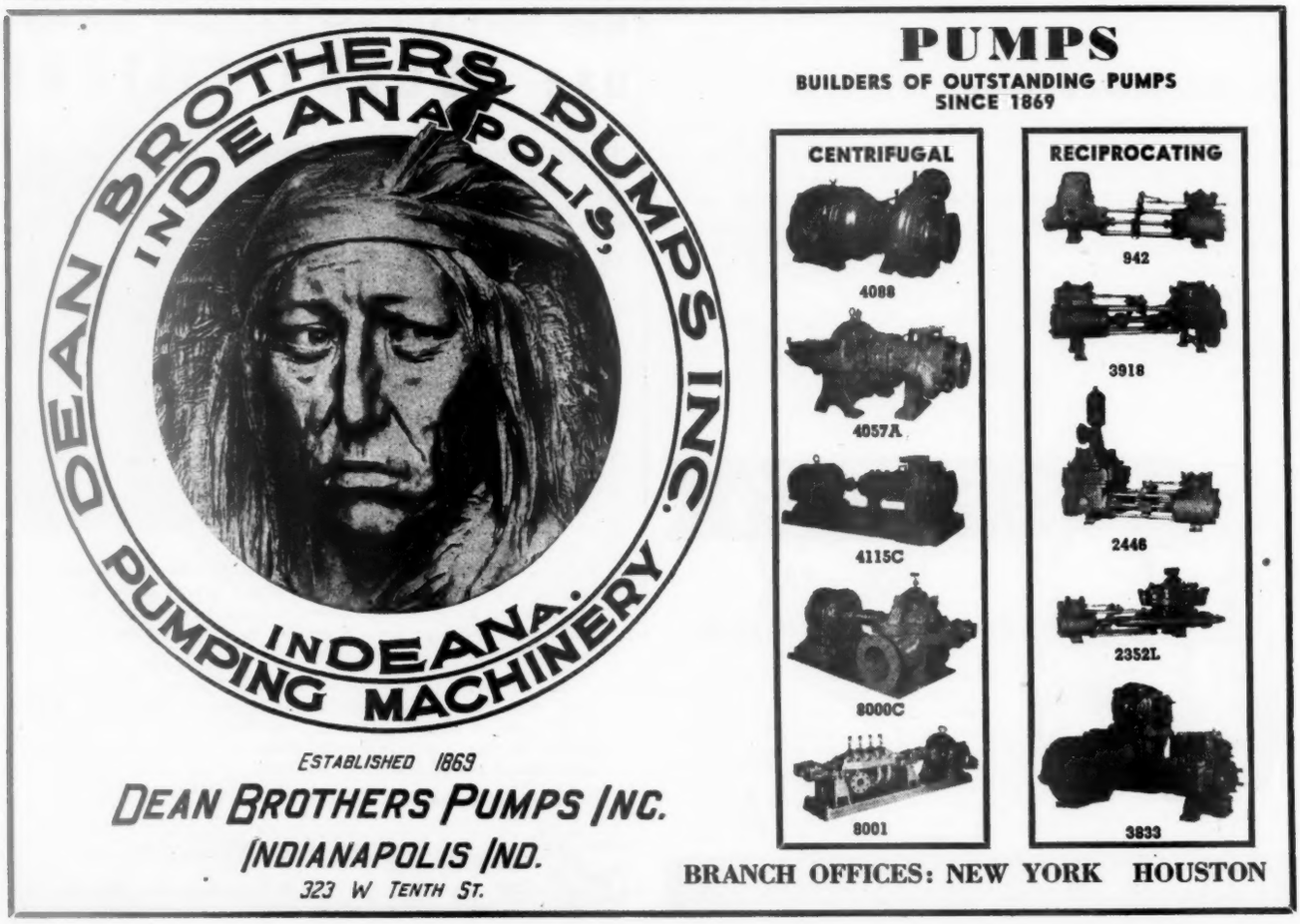
"Operation is only feasible, in the face of these very high costs, because of the great production possible. If the limits imposed in many states in this country, on the amount of oil that can be taken from the ground, were to be put in force in Venezuela, it would be impractical to produce there.

"Petroleum reserves in Venezuela are tremendous and only partially known, in spite of the fact that operations were under way as long as 30 years ago. And even less is known about the reserves of other natural resources within the country, although the best informed surveys indicate that the country's mineral wealth is so great that many kinds of exploratory mining operations can be easily justified on the grounds of high productivity."

Is it necessary because of shipping time and distances, to carry substantial maintenance stocks. Gottwald said, "The companies down there operate extremely large stores departments, and in spite of the fact that there is also a good deal of interchange between companies, emergencies necessitate ingenuity in working out substitutes. As a result, most experienced buyers in Venezuela are looking for the best obtainable equipment. With costs already high, a slight additional cost to the original price is not a major item; dependability is far more important. It is definitely a 'quality' market."

The government requirement of employing native help is resulting in company training programs that are beginning to produce competent junior engineers, Gottwald reported.

"Up to the present, the technical help and management has all been American, British, and Dutch, but 20 years from now, and perhaps sooner, the balance will be with the natives. That poses a marketing problem, too, for although major buying is still with English speaking engineers, maintenance specification is coming very rapidly to rest with natives coming up through the various companies. Consequently, some attention must be given, both in language and in an understanding of the native background, to these young engineers and operators, in maintenance manuals and similar operating literature."



A.P.I. district meeting

The regular spring meeting of the Southwestern District API Division of Production, will be held on May 17 and 18, at the Washington-Youree Hotel in Shreveport, Louisiana.

The Ark-La-Tex Chapter of the Production Division at Shreveport, B. J. Dowd, chairman, will be the official host for the meeting. Dowd and his associates were instrumental in the appointment of the committees that will handle the various details in connection with the meeting.

The management of the Washington-Youree Hotel has agreed to cooperate in every way possible and has requested that hotel reservations be made promptly. Some of the other hotels in Shreveport are: Rex Hotel, Jefferson Hotel, Inn Hotel, Gardner Hotel, and Caddo Hotel.

The program committee under the chairmanship of Dr. W. V. Vietti of The Texas Company at Houston is already at work and has several constructive papers in prospect.

Dean of petroleum geology

"So that the record of his achievements and the estimate of his worth, as given by his contemporaries, might be preserved for the inspiration of his descendants, and as a memento for his friends and former associates, these tributes to the memory of William Warren Orcutt, together with articles of historical interest, as published in the bulletins of the various organizations to which he was allied, have been assembled in book form by his wife, Mary Logan Orcutt." Thus reads the scroll that is the foreword to the "Memorabilia of William Warren Orcutt," a fitting testament to the life and works of one of the greatest figures of western industry. Appropriately inscribed at the bottom of the same page is the line, "A good name is rather to be chosen than great riches."

W. W. Orcutt

Spending his childhood in Santa Paula, the birthplace of the California petroleum industry, W. W. Orcutt became a member of the first graduating class of Stanford University, a classmate of Herbert Hoover, and a football player under the direction of the famous coach, Walter Camp. Upon his graduation, he returned to Santa Paula, where his efficient handling of various assignments made such an impression on Lyman Stewart, that he was offered and accepted a permanent position with Union Oil Company of California. Three years later he was appointed geologist and engineer, the first significant step in a long and colorful career.

Known affectionately to all geologists as the "dean of petroleum geology," Orcutt was responsible in no small way for converting the business of petroleum finding from a haphazard adventure to a highly scientific process. So successful was he, indeed, in the application of geology to exploration that he is credited with the discovery of more California oil fields than any other individual; and many of the methods that he developed and practiced in the pioneer days of petroleum geology are still standard with the industry. He made the first geological maps of such areas as Coalinga, Lompoc, and Santa Maria, organized the first petroleum geological department on the Pacific Coast, discovered the famous La Brea fossil beds in Los Angeles, and was made an honorary life member of the American Association of Petroleum Geologists for his "outstanding efforts in developing the oil decline curve used in appraising oil resources." He was a member of Union Oil Company's board of directors for 34 years and a vice president for 20 years.

Perhaps more to be remarked than his business success were his wholly human traits and characteristics: A strong, rugged man, with a rather subdued voice, he had a keen sense of humor and an inexhaustible fund of interesting anecdotes, all of which came from first hand experience. He traveled with little or no equipment into all sorts of unknown places, and at all seasons, and he found life highly amusing where others might find reason to complain of hardship. He knew and was known by the Basque sheep men of the San Joaquin Valley, and to field men in Southern California generally, his was a familiar and a welcome figure.

"Memorabilia of William Warren Orcutt" is a memento of a life of genuine accomplishment in the industry. Mrs. Orcutt had the book printed by the Fred S. Lang Press of Los Angeles.

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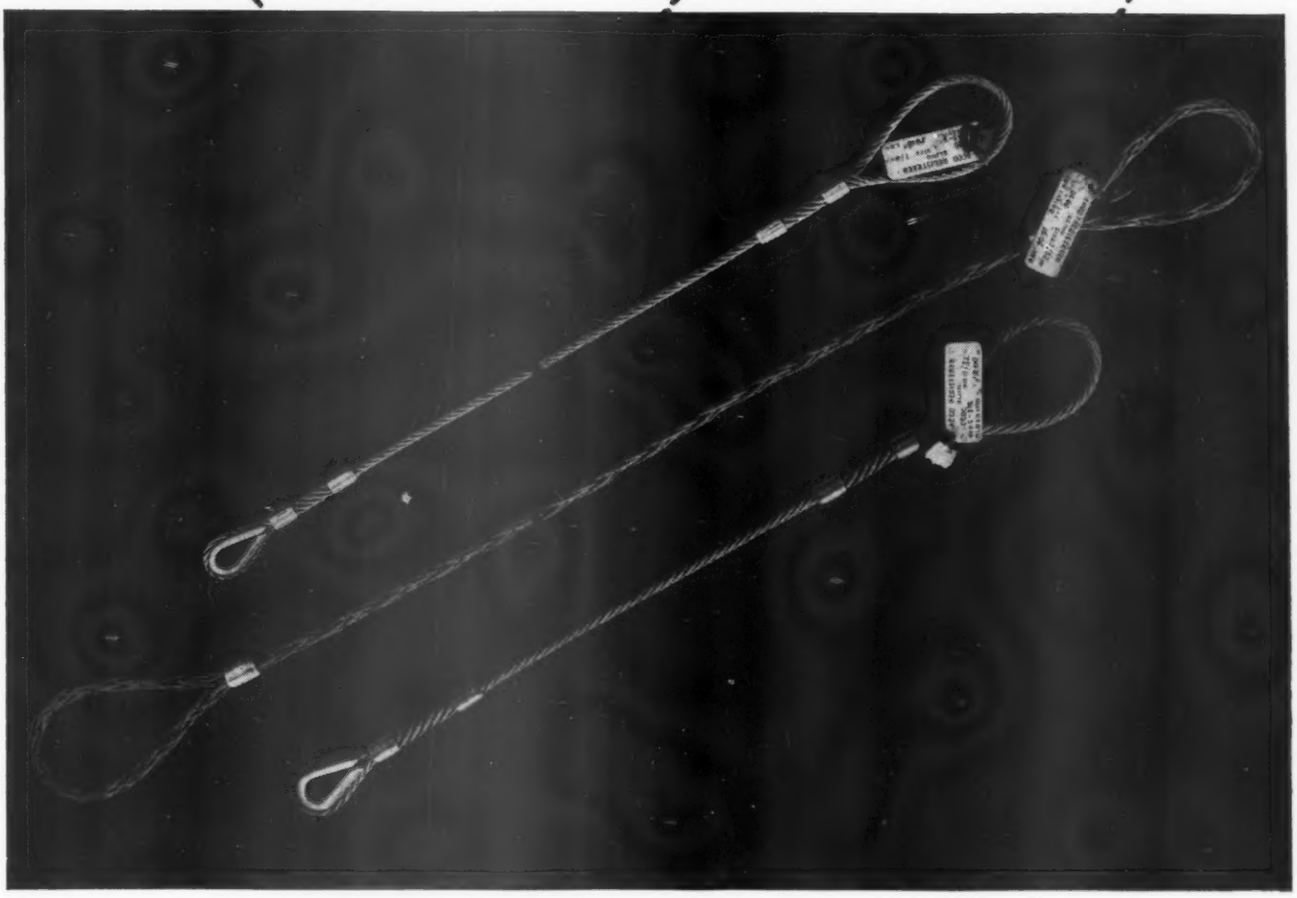

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